AMATEUR TALKING PICTURES AND RECORDING

B. BROWN

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LONDON
SIR ISAAC PITMAN & SONS, LTD.
1933

SIR ISAAC PITMAN & SONS, LTD.
PARKER STREET, KINGSWAY, LONDON, W.C.2
THE PITMAN PRESS, BATH
THE RIALTO, COLLINS STREET, MELBOURNE

ASSOCIATED COMPANIES
PITMAN PUBLISHING CORPORATION
2 WEST 45TH STREET, NEW YORK

SIR ISAAC PITMAN & SONS (CANADA), LTD.
(INCORPORATING THE COMMERCIAL TEXT BOOK COMPANY)
381–383 CHURCH STREET, TORONTO

PRINTED IN GREAT BRITAIN
AT THE PITMAN PRESS, BATH

PREFACE

CINEMATOGRAPHY has established itself as a hobby. Professionally the talking picture has ousted the silent. Combine the two statements and the object of this book appears.

The ordinary gramophone is out of date, radio is almost commonplace, and television is somewhere in the future. The home talking picture might well fill the gap.

Many people are not aware that the home talking picture is already with us, and that scores of firms both in America and Great Britain have produced equipments, some expensive and some cheap. In Chapter X is described one very promising system which might, if properly developed, place the home talkie in a million homes at an initial cost less than radio.

Home recording is naturally closely related to talking pictures. It is given first place in this book for clearness of exposition.

While a number of talking picture equipments are described in the following pages, they must not be thought the only ones.

Obtaining data for a relatively new hobby means a considerable amount of experimental work if the field is to be treated fairly. Most of the British sets described have been tested personally, and in one instance involved the use of a studio for some weeks.

I have to thank those companies mentioned beneath the illustrations and in the text both for the photographs and for the help they have afforded.

Besides these I wish to express my gratitude to: Merritt Crawford, Esq., D. A. Trafton, Esq., Herman A. De Vry, Esq.,

R. C. A. Victor, Pathegrams Inc., Ampro., Harlie Bros., British Aluminium Co., Standard Kine Laboratories, Amateur Cinema League, *The Screen*, *Projection Engineering*, *The Broadcaster and Wireless Retailer*.

BERNARD BROWN.

West Hill, London,
1933.

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AMATEUR TALKING PICTURES AND RECORDING

CHAPTER I

HOME RECORDING

Development and Principles. Since this book is essentially of a practical character, we shall be content with a brief description of the development of sound recording. It began as an invention of Leon Scott, patented in France in 1857 and known as the *Phonautograph*. In brief this consisted of an arrangement having a barrel-shaped cylinder, the prototype of the modern microphone, at the end of which was fixed a flexible diaphragm. At the centre of this latter was a needle which vibrated as words were spoken down the barrel. By means of a rotating cylinder coated with lampblack a visual record of sound was made.

The telephone, patented by Graham Bell in 1876, was doubtless the forerunner of the *Phonograph* invented by Edison in 1877. Actually the phonograph was similar in principle to the *Phonautograph*, but was a great step forward in that, besides recording sound, it did so in such a manner that it could be reproduced. Edison employed a sheet of tinfoil wrapped round a cylinder into which the vibrating needle cut its path. At a later date he introduced cylinders of a wax composition as many readers will remember.

Although the phonograph enjoyed a period of considerable popularity it was not until the flat disc type record, since associated with the gramophone, was introduced by Berliner in 1887 that the instrument as we know it to-day was initiated.

Most of us think of the gramophone and phonograph as

means of entertainment, but the original idea was utilitarian. Obviously great benefits might result by any device which could take down the spoken words of an individual and reproduce them at any later period. When the flat type of disc made its appearance the phonograph, using "jampot" cylinders struggled on for a time, but after a while restricted its efforts to business spheres. This principle is employed extensively at the present day in the form of dictating machines, of which we shall speak further. In the meantime the gramophone made rapid strides forward until a few years ago it might have claimed to be the most popular home entertainer. At the time of writing it would appear that its place of supremacy has been usurped by radio.

Sound. Before we proceed to discuss principles of recording we had best deal with fundamental terms. First of all sound has nothing to do with wind or air. Certainly most of the sounds we hear are transmitted by air, simply because that is our natural medium. On the contrary, fish and other water animals hear by the medium of water.

Put briefly, we can say sound is vibration in a transmitting medium which, from the point of view of sound recording, we can consider as air.

There are two other factors associated with sound which we shall have to define. The first of these is *intensity* or *loudness*, sometimes known as *volume*. This is self-evident, for we appreciate that some sounds are louder than others. One point, however, is that when we say that one sound is twice as loud as another we usually make a mistake. An increase of 100 per cent in volume is only just audible to the ear. We shall not go farther into the explanation of this except to state that for theoretical reasons volume is measured on a type of logarithmic scale.

The second factor of sound is that known as *frequency* or *pitch*. We are aware that some notes are shriller than others. Actually frequency or pitch is measured by the number of vibrations per second caused in the transmitting medium. Vibrations over 16 per second are audible as sound. We can specify the pitch or frequency of a note either by reference of the number of vibrations per second or to the musical scale. These are related, and if we know

that a certain note is equivalent in pitch to Middle C in music, we know at the same time that vibrations are occurring at a frequency of 256 cycles per second.

The Musical Scale. In Fig. 1 we see a representation of the musical scale as applied to the keyboard of a piano. Associated with the keyboard is a scale of frequencies

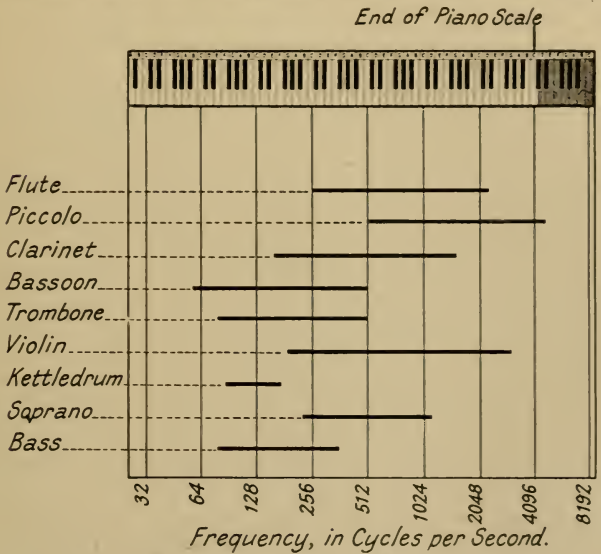


FIG. 1. FREQUENCY AND THE MUSICAL SCALE

whereby comparison can be made. Beneath the keyboard are various musical instruments and vocal performers, and the length of the black line indicates the range of the notes. Thus we see the piccolo reaches the highest notes—something over 4,000 cycles per second—while the bassoon scores on the lower scale at just under 64 cycles per second. The difference between the soprano and the bass is also apparent.

It may well be asked how high and how low on the musical scale can we actually hear. Although this varies with individuals, the average is between 20 cycles per second and

20,000 cycles per second, always providing that the sounds are of a suitable loudness. Clearly it would be possible to make a very "quiet" sound of a pitch, which under suitable circumstances we could hear, yet which was so low in volume as not to be perceptible. The same thing could occur by reason of excessive distance from the source.

Although the limits of the human ear are as stated above, the voice range is different, being from about 50 to 8,000 cycles per second.

This immediately raises an interesting point in that there must be some sounds more difficult to record than the human voice.

Referring again to Fig. 1, however, we find that the piano scale ends under 5,000 cycles per second. It might be thought that this indicates that the human voice extends further in range than musical instruments. This is not necessarily so, for our diagram relates to what are known as fundamental notes. In music, however, we rarely if ever get an isolated fundamental. Usually with it are associated harmonics.

From our point of view we can regard these as other notes or "echoes" set up by the interaction of a number of fundamentals. Harmonics produced by notes of a frequency of two or three thousand may extend in range to 20,000 cycles.

This may appear somewhat complicated, but actually it explains the difference in tone of, say, Middle C struck on a piano and sounded by a violin. The fundamental is the same in both cases, but the actual quality of the note is different, since with each fundamental are associated special harmonics. It is the harmonics which give the illusive tone quality to different sounds, and thus in sound recording we strive to include as large a range of frequencies as possible.

For the sake of argument a modern telephone in good condition transmits voices with reasonable clearness. At the same time, however, it could not be considered as anything in the nature of pure transmission. In telephone work it is clearness for which the engineers strive. In sound recording we must also have quality, and those illusive

properties which distinguish one musical instrument and one voice from another.

The Gramophone Record. Everyone is familiar with the appearance of modern gramophone records, consisting as they do of flat discs bearing a long spiral groove which usually starts at the outside and works inwards. If we examine a section of these grooves under a magnifying glass we shall find they appear as shown in Fig. 2, where it is apparent that the spiral does not follow a uniform curve, but is wavy in formation. How does this come about?

(*Western Electric Co., Ltd.*)

FIG. 2. MAGNIFIED RECORD GROOVES

Suppose we have an arrangement as shown in Fig. 3, where a flexible diaphragm is situated at the end of a type of horn. To the middle of this diaphragm is attached a link which in turn is coupled to a light rod pivoted to a fixed body, and at the end of this rod remote from the diaphragm is a cutter which rests against the surface of a rotating slab of wax. If we rotate the wax we trace out a shallow circular groove upon its surface. Now if we enunciate words into the horn while this shallow groove is being cut, the flexible diaphragm will vibrate as indicated by the dotted lines, and thus move the lever and the cutter. This will cause a wavy type of groove as indicated in the figure, which will be similar to that already observed in Fig. 2.

We shall not, of course, with this crude arrangement be cutting a spiral but merely a circle. It is, however, easy to imagine an arrangement whereby, as the wax turns round it is gradually fed towards the cutter, thus causing a spiral to be traced. This, in brief, is the principle of recording gramophone records. Actually until 1925 all commercial

records were produced by a process very similar to this, but from that time electrical methods were adopted.

This same principle, which we shall know as "acoustic recording," is employed still for more simple home recording.

We have just explained that sound has two principal factors, namely intensity and frequency. How are these recorded in the single wavy curve?

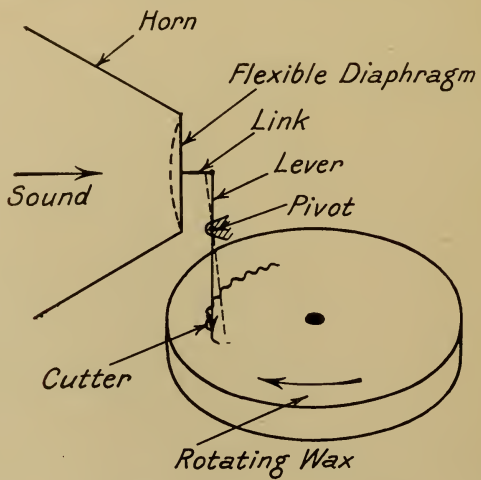


Fig. 3. Sound Recording

Evidently frequency, since it depends upon the occurrence of vibrations so many times per second, must be given by the number of peaks or wavy formations in the groove. The time element is introduced, since the disc rotates at a uniform speed.

The question of loudness will be explained by Fig. 4, where we see two sound grooves *A* and *B* having the spacing or frequency of the waves precisely similar. The loudness or intensity of *B* will, however, be considerably greater than in *A* since the amplitude is more.

To explain a little further we may say that these two factors, intensity and frequency, are reproduced by different

motions transmitted to the reproducing needle of the gramophone. The frequency is caused by the number of sideway movements of the needle per second, while the loudness of the sound produced depends on how far the needle moves, or in other words, the "swing" of the groove.

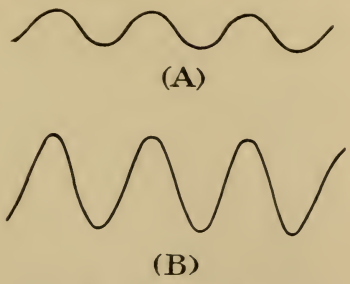


FIG. 4. PRINCIPLE OF DISC RECORD

The Gramophone. Fig. 5 illustrates the principle of an acoustic gramophone—really the converse of the arrangement shown in Fig. 3. First we start with a needle which is specially shaped to fit the grooves of the record. The groove shape adopted is shown

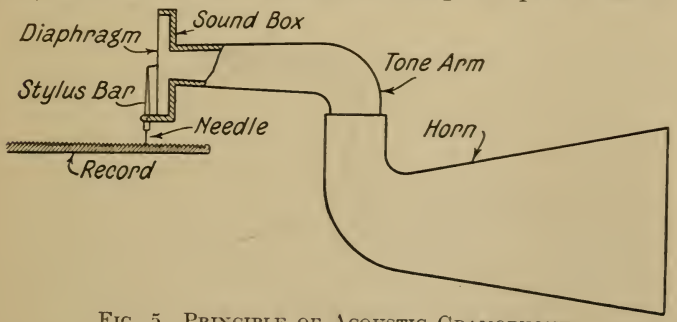


FIG. 5. PRINCIPLE OF ACOUSTIC GRAMOPHONE

in Fig. 6, where the dimensions will be seen. A photomicrograph of a section of a record is shown in Fig. 7, where the point of the needle also appears.

The needle is gripped in one end of a link known as a stylus bar, as seen in Fig. 5. This is attached to the middle of a flexible diaphragm which is carried by the sound box. In turn this is attached to a tone arm, which is really the neck of the horn. The tone arm is arranged mechanically so that the sound box can be thrown back for easy insertion

of the needle, and so that the needle can follow the spiral groove from the outside of the record inwards. Briefly it is merely a flexible neck. The horn itself may be of a variety of shapes, although theoretically there is only one which can give perfect results.

The record, as we know, is placed upon a turntable, to which it is held sufficiently by friction. Usually the top of the turntable is covered with velvet or felt, not only from the point of view of appearance but from that of preventing scratches to the record and securing adequate driving friction.

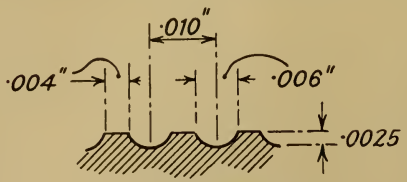


Fig. 6. Standard Record Groove Size

With acoustic gramophones, i.e. those not employing electric amplification, the motor turntable is usually of the spring driven variety. Since obviously it is of the greatest importance that frequency is constant and correct, a governor is fitted. The construction of gramophone motors has reached a fine art, and modern machines rarely give trouble in this respect.

We do not propose going deeply into the theory of the acoustic gramophone, since our scope lies in other directions. One or two points of importance are, however, noted below.

The Sound Box. The sound box of even the most expensive gramophones is still a relatively simple affair, but it must not be thought for this reason that it achieved its present form easily. As a matter of fact the modern sound box is the result of an enormous amount of research and still more "cut and try." Take, for instance, the case of the stylus bar. The amateur, after carefully considering its functions as a transmitter of motion from the needle point to the centre of the diaphragm, would think immediately that it might better be constructed of a light alloy such as aluminium and not of steel, as is universal. It might be theorized that we can obtain a light alloy practically as stiff as steel, and its very lightness should increase the amount

of power transmitted to the centre of the diaphragm, and thus converted into sound. As a matter of fact, liter-

(*H. Bulstrode, Esq.*)

FIG. 7. SECTION OF GRAMOPHONE RECORD SHOWING NEEDLE

ally hundreds of experiments have been carried out on different metals for the construction of stylus bars, and so far nothing has been found which equals steel!

In the early days diaphragms were constructed of a plain

mica sheet, which in more recent years has given place to variously shaped diaphragms of aluminium. It can be taken at the present day that best results are obtained from aluminium diaphragms cupped in the middle according to principles discovered in the past few years for producing greatest volume consistent with quality. In this connection the reader should examine the types of sound boxes produced by companies such as the Columbia Graphophone Co., and the Gramophone Co. (His Master's Voice). The diaphragm of the Columbia Co. is made in two pieces, the centre one of which is thicker than the outer anulus. The Gramophone Co.'s instruments have a diaphragm somewhat similar in shape but differently formed. Both of these sound boxes may be considered the high water mark of development in this direction.

The pivot for the stylus bar has also received great attention. Nowadays most of these pivots are of the ball bearing variety. It might be thought that so little movement takes place that a ball bearing would surely be a luxury. As a matter of fact, although the movement is very slight and the load carried infinitesimal, vibration takes place so rapidly that ball bearings make an appreciable difference in volume as well as quality.

The design of the remainder of the sound box has also received a great deal of attention. Most modern sound boxes are attached to the tone arm by means of some sort of flexible connection. Some employ springs and some rubber pads. The reason is that this arrangement has been found to give better bass reproduction.

The tone arm itself has been attacked in many directions to determine the best "taper" and neck diameter in relation to the diaphragm.

On the question of horns more patents have been filed than there are pages in this book. The ideal horn should follow a curve of the type known mathematically as exponential. Still, for commercial and practical purposes we have to compromise and modern horns give very good results while occupying minimum space. If one of the larger type acoustic gramophones be examined an astonishing length of horn is revealed packed into a small space. In one type

adopted by the Columbia Co. a system known as "Plano-Reflex" has been adopted, where, instead of using a horn tapering along the full length, a series of diagonal flats is employed for directly "reflecting" sound. This principle has also been extended to the Columbia tone arm.

Theoretically the lowest note which can be reproduced by a horn depends upon the length and width of the mouth. Thus to reproduce sound as low as 64 cycles per second the horn should have a mouth 6 ft. wide and be 14 ft. long. Obviously this is out of the question for ordinary gramophones, and thus our lower cut-off will be considerably above 64 cycles per second. This theory does not, however, always entirely work out in practice.

In the early days all gramophones were blessed with large horns suspended above the turntable. Nowadays they are concealed in cabinets but they are still there. Even in the case of portable gramophones the best still have a horn, usually about 4 ft. long. This may seem somewhat remarkable in view of the smallness of the size of the case, but the horn usually traverses from one end of the case to the other, and back again and then upwards through the tone arm to the sound box, thus achieving the figure mentioned.

Progress of Home Recording. The early experiments of Edison were definitely of the home recording variety, and it will be remembered that the first spoken words to be recorded in this manner were the lines of "Mary had a little lamb."

When phonograph records were placed upon the market they appeared as wax cylinders some 2 in. in diameter by 6 in. long. The recording of these took the form of "hills and dales," and not the wavy groove as adopted later by the gramophone. To explain in a different manner we can say that while the groove of the gramophone record ran from side to side, that of the phonograph went up and down.

Soon after the introduction of the phonograph, special blank wax cylinders were provided for home recording. A special type of sound box was supplied for recording which replaced that employed for reproduction. It will be

remembered that in the case of the Edison phonograph ball-ended sapphires were employed in the place of the steel gramophone needles adopted for the flat type of records. For recording the ball sapphire was replaced by one with a sharp cutting edge which scooped or dug into the cylinder as it revolved, and thus cut out a hill and dale groove.

The results obtained by home recording in this manner were very good indeed, and the writer has recently heard some wax records, made some twenty years ago by this process, which were comparable in quality to amateur acoustic recording of to-day.

The early gramophone made no pretence at being a device for home recording, since it lacked the mechanical perfections of the phonograph, and furthermore could not employ wax records.

This brings us to another interesting point, namely the reason for the supremacy of the gramophone with its flat disc over the phonograph with its cylindrical one. The usual reason given is that the flat disc packs away so conveniently. There is a certain amount of truth in this, but this is not the real reason why the gramophone ousted its rival. It is a relatively easy matter to reproduce gramophone records when once the "master" has been made. We examine this matter a little further later on, but for the time being we can consider that gramophone records are stamped out in quantity much after the style of tin lids and similar press work. The phonograph record, on the other hand, was moulded or cast, which means that a cylindrical mould was produced and molten wax poured in. Even then difficulty was experienced in withdrawing the moulded record without damaging it, and to this end the cylinders were made slightly taper. In spite of all this it was fundamentally impossible for a phonograph record to be reproduced anything like so cheaply as a gramophone record, and so the phonograph faded, and the gramophone usurped its place. In fairness, however, it may be stated that fundamentally the principle of the phonograph was immensely more sound than that of the gramophone.

With the fading of the popularity of the phonograph so went that of home recording. But the phonograph did not

die except as a home entertainer, for it gradually took its place in the world's work as a dictating machine.

Thus while the public had forgotten the art of home recording it was still employed under their very noses in the form of machines for replacing the shorthand-typist.

Only in the past few years has interest in home recording again been revived. In all probability this was due to a rival art—or should we say science—radio. Someone conceived the idea that it would be fascinating to record selections from radio programmes, and thus once more home recording came to the fore.

At the present day there are many dozens of different types of home recording outfits on the market employing different mechanical principles, and with several differences in recording media. It is probable that in the near future home recording will become an essential of modern life, as might be said to-day of radio.

Electric Recording and Reproduction. In 1925 the gramophone companies introduced electric recording. This was one of the developments following the invention of the thermionic valve which rendered it possible for minute electrical impulses to be amplified or magnified to any desired level.

The principle of the ordinary telephone transmitter is too well known to require elaboration. Briefly the sound causes a diaphragm to vibrate which by alternate pressures and relaxations upon carbon granules alters the resistance of an electrical circuit. This makes it possible to convert sound into electrical impulses and *vice versa* by the use at the other end of an electro-magnet complete with another diaphragm. As the electrical impulses vary so does the pull of the magnet, thus causing the second diaphragm to vibrate in precisely the same manner as the first. This principle was not extensively adopted for gramophone work, or perhaps we should say sound reproduction, for the simple reason that it gave no appreciable gain in volume. There was no reason at all for transferring the impulses from one diaphragm to another if during the process we did not acquire extra loudness.

The introduction of the thermionic valve in the form of a valve amplifier rendered it possible to take the initial

feeble electrical impulses and magnify them to any desired extent before reconverting them into sound by some type of telephone receiver, preferably of the loud speaking variety.

Before electric gramophones became possible, however, the amplifier was used for recording purposes in the making of records. This was fundamentally right, since the greater we amplify recording the more apparent become its imperfections. The right step, therefore, was first of all to improve the process for making the records and then the apparatus for reproducing them.

The older method of acoustic recording under proper conditions produced excellent results, but it had severe limitations. In the first place it was necessary for the vocalist or entertainer to get close to the mouth of the horn. This was perfectly satisfactory when only one or two persons were involved, but when whole orchestras had to be recorded arm room was somewhat cramped! Then again, another difficulty was encountered due to the natural period of vibration of the diaphragm used in the acoustic recorder. All bodies have natural period of vibration, and when a note impinges on them of the same frequency we get a rise in level of the general sound. In playing an ordinary acoustic gramophone, for instance, we sometimes hear a shrill type of chatter, which is exceptionally objectionable. This occurred also in recording.

The elementary principles of electrical sound recording are illustrated in Fig. 8, where we find the sound impinges on a microphone, whence it is converted into a fluctuating electric current which passes to a valve amplifier, and thence to the recording head of a machine. This machine consists of a motor for rotating a flat wax disc. The recording head is designed so that the amplified electrical impulses from the valve amplifier cause a cutter or recording stylus to waggle backwards and forwards as with the acoustic system in Fig. 3. At the same time as these impulses are being received by the recording head the latter is drawn across a radius of the wax disc by a lead screw, which is operated through suitable gearing from the main driving motor. Incidentally it will be noted that the power for driving the turntable is furnished by a gravity motor, i.e. power is

developed by a falling weight. This principle is still employed at the present day by the gramophone companies.

The recording head itself is simple in principle, and is illustrated in Fig. 9, where we find an armature pivoted in the gap of an electric magnet. Around the top of the armature is a speech coil through which flow the impulses originally starting in the microphone. The direct result of this fluctuating current through the speech coil is to cause the

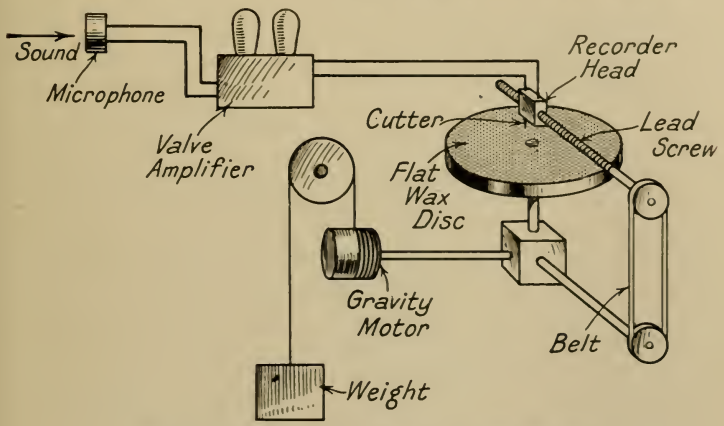


FIG. 8. PRINCIPLE OF ELECTRIC RECORDING

armature to vibrate in a manner precisely similar to that of the diaphragm of the microphone which corresponds to the sound vibration proper. At the end of the armature is fitted a sapphire cutter which traces out the groove. The lower illustration of Fig. 9 shows details of the sapphire cutter employed in ordinary record making.

Attached to the pivot of the armature is a tube of rubber for damping resonant vibrations.

The Electric Gramophone. Since the acoustic recorder and the acoustic gramophone are very similar and can, at least in the case of the phonograph, be used almost interchangeably, it might be reasonable to inquire whether or no this same rule holds true for electric recording devices. Thus, if putting the fluctuating electric current through the speech

coil of the electric recorder shown in Fig. 9 causes the armature to vibrate, is it not reasonable to suggest that if we cause the armature to vibrate we shall set up fluctuating electric currents in the speech coil which could possibly be amplified and operate a loud speaker?

This, as we know, is actually the case, and in modern home recording we usually work backwards, i.e. we employ

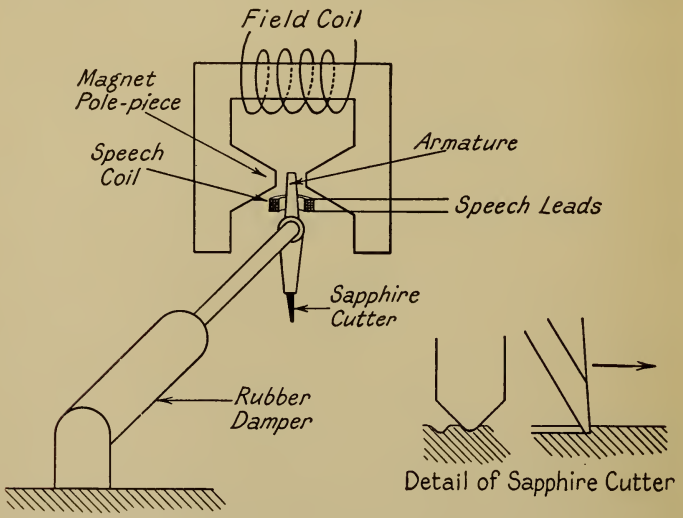


Fig. 9. Electric Recorder Principle

what has become known as an electrical pick-up for recording.

The usual form of electrical pick-up in use at the present day is illustrated in principle in Fig. 10, where the arrangement is similar to that of Fig. 9. The only difference apparent is that instead of using an electric magnet we employ a permanent one, usually of cobalt steel which gives a high flux density with minimum weight. The damping rubber is removed to a more convenient position.

The electrical method of reproduction of gramophone records possesses several advantages over the old acoustic system. Firstly, it can give any volume required simply by

applying the requisite amount of amplification. Secondly, with properly designed equipment the frequency response, or naturalness of the reproduced sound, is better than that of the acoustic machine. In the past few years it has become somewhat general to ridicule the quality of the acoustic gramophone when compared with the electric machine. This attitude is scarcely justified by results. It is true that

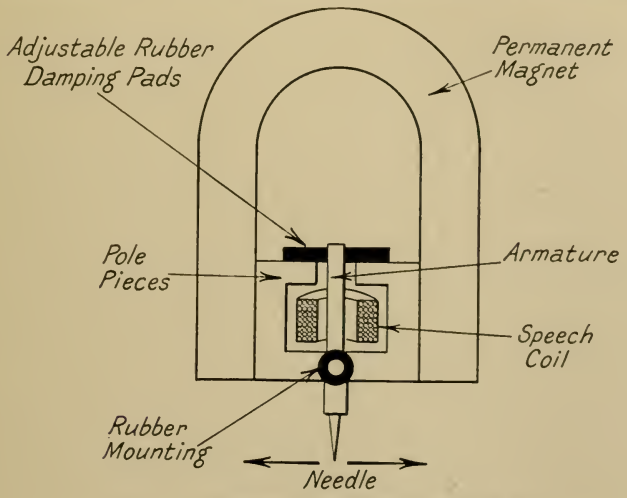


FIG. 10. PRINCIPLE OF ELECTRIC PICK-UP

a good electric gramophone is superior to a good acoustic one, but even at the present day there are not too many really good electrical gramophones on the market. Many of these sold as such are really adaptations for utilizing the valves of a radio set for playing gramophone records. Experience shows that an electrical gramophone must be designed as such, and not merely as an adjunct to a radio set, if really first-class results are desired.

Principles of Home Recording. The apparatus for home recording is similar in principle to that employed in the gramophone studios, although it is naturally not so elaborate nor is it capable of giving such excellent results. For

the sake of economy we generally use the same apparatus for recording as for reproducing. Even in gramophone recording studios a recording machine is sometimes employed for "playing back" as a check on performance.

It is with the medium of recording, the record or disc itself, that difference is encountered. To explain further we must trace briefly the story of the modern gramophone record.

As mentioned before, professional recording takes place on wax discs, which are shaved to a super-fine finish in special machines. After the wax has been recorded it is plated, sometimes with copper and sometimes with gold. To render plating possible the wax surface is first made electrically conductive by brushing with fine graphite powder. Alternatively the wax is plated by bombardment in a vacuum chamber after the style of the electronic action in a radio valve. The thin plating is then backed by further deposition, and the shell is then stripped from the wax and becomes the "Master" negative in which the originally recorded sound grooves appear as raised lines. Obviously this master could be employed for pressing records similar in form to the original wax.

Record pressing is very simple. A mould is fixed in the jaws of a steam-heated press, and upon it is placed a lump of moulding compound, usually a mixture of shellac, copal, and resin as bonding agents, with slate powder and carbon black as fillers. The press doors are then closed by hydraulic power exerting a pressure of about two tons per square inch, and in less than a minute heat and pressure have done their work, and a modern miracle is wrought in the form of a gramophone record. The steam is cut off and the mould chilled by water when the finished record is removed.

For commercial pressing of records the masters are not employed. From them by another electro-plating process is made a "*Mother*" shell, and from this a "*matrix*." This *mother* gives us a copy of the master which itself is kept for further reproductions, and is not employed in pressing. The development of the process, although very complicated, has been brought to such a fine art that practically no quality is lost in transference.

For home recording all this elaboration is obviously out of the question, and a more simple solution must be sought. We cannot employ wax conveniently in the disc type records, because the grooves have to be sufficiently strong to support the weight of the sound box or the electric pick-up imposed upon the needle point. In phonograph recording wax was employed, but it will be remembered that the movement of the sound box took place through the medium of a lead screw somewhat after the style of that employed in modern recording machines, and the weight was suitably balanced.

Let us consider what material we must employ for our home recording. Briefly the properties necessary are as listed below—

1. It must be soft enough to enable the groove to be cut without excessive effort. This is especially necessary if we are employing acoustic recording. In the case of electrical recording we might, of course, use any amount of power by suitable amplification, but this would not be advisable since we do not wish to increase our amplification above that usually employed for electric gramophones or radio sets.

2. The material employed must preferably be ready for immediate reproduction as soon as recording is complete. We do not wish to put it through a series of processes similar to those of the commercial record.

3. The material must be such that besides fulfilling the requirements as given in Paragraph 1 above it will retain a perfect impression as cut by the recording stylus. Certain materials might be soft enough to take a blurred impression, but this would be useless, since we wish to record a reasonable band of frequencies, say between 100 cycles and 5,000 cycles.

4. After satisfying the above conditions the material must also be capable of playing for a good number of times, say, somewhere in the region of one hundred, before losing quality of reproduction. One hundred may seem low, but it should be mentioned that the commercial gramophone record itself does not retain first-class quality reproduction over a hundred playings—sometimes considerably fewer!

Many, many materials have been tried with varying

success, but at the present time we can consider that only two have survived. They are aluminium, either in the pure or alloyed state, and a new type of resin having an appearance and characteristics in some ways similar to celluloid.

In Chapter III we shall describe a number of varieties of equipment and methods adopted for utilizing these discs. Although the varieties are legion they occupy themselves mainly with the methods employed in effecting the inward movement or traverse of the recording head or electrical pick-up. This may appear a simple point, but it has occupied the time of many inventors.

CHAPTER II

ELECTRICAL DATA

As will have been gathered from Chapter I, principles of acoustic and electrical recording are identical. Sound causes a diaphragm to vibrate, which by some means is transmitted to a cutting stylus which marks out a spiral groove on a rotating disc. In the case of acoustic recording the cutter is applied direct to the diaphragm, whereas in electrical recording we have an intermediate amplifier.

Before we can proceed to discuss some of the equipments on the market for carrying out this work there are several points in connection with electrical amplification with which we must deal. The subject of electrical amplification if treated thoroughly is a complex one, and most of it is outside the present scope. Those having knowledge of radio work must excuse the elementary nature of the treatment.

The Valve Amplifier. The valve amplifier is simply a means of proportionally magnifying an electric current. Thus coming from our microphone we have a feeble and constantly varying electric current which is insufficient for our needs. This is put through an amplifier, whence it emerges magnified in amount but still bearing precisely similar variations.

As a matter of fact the current which goes to the input terminals of an amplifier does not actually emerge from the output terminals, but instead we get another but larger current.

In a number of the home recording equipments at present on the market special amplifiers are supplied if required, but a good many amateurs already possessing radio sets or amplifiers will not wish to bear this additional and probably unnecessary expense. What, then, is the criterion for an amplifier suitable for home recording?

First of all it should have a straight-line characteristic, which means simply that if we impress a series of fluctuations on the input terminals these will be reproduced

precisely from the output terminals though in a magnified form. To make an amplifier which gives perfectly straight line amplification is a difficult matter, but most of those at present marketed by reputable firms are sufficiently good for home recording.

The next criterion of the amplifier is that it amplifies sufficiently to work a recording head (actually a pick-up). Generally speaking, most radio sets or amplifiers working from the mains and employing mains valves will possess sufficient power to work an electric recorder. Nevertheless the greater the amplification the greater will be the scope. Battery-operated radio sets or amplifiers can also be used providing they are sufficiently powerful.

The usual method of estimating the power of an amplifier is by stating its output in milliwatts. This may be found very simply by the following formulae.

Triode Valves. Output in milliwatts

$$= \frac{\textit{anode current in milliamps} \times \textit{anode volts}}{5}$$

Pentode Valves. Output in milliwatts

$$= \frac{\textit{anode current in milliamps} \times \textit{anode volts}}{3}$$

It is somewhat difficult to set the minimum power required for electric recording, but we might say that 500 milliwatts is a fair standard, and this will require some care in operation if good results are to be obtained. In the experience of the writer a convenient value of output is about 2,000 milliwatts, which corresponds roughly to that of the modern indirectly heated pentode valves.

In making a choice of amplifier for home recording the question of portability must be considered. If we wish to carry equipment from one place to another then obviously the battery amplifier is most suitable. On the other hand, if we intend to record only at home, then undoubtedly the mains operated variety is preferable, since it is cheaper to run and produces greater power. This same question relates also to the choice of a motor-spring or electric for driving the turntable.

Amplifier Connections. In Fig. 8 is a pictorial lay-out of electrical recording including mechanical features of turntable, etc. In Fig. 11 we have the electrical recording circuit which should be studied with care. Starting at the left of the diagram is the microphone, and running from it the leads go to one side of a transformer. Since the microphone by itself is incapable of generating electric current, a battery is included in circuit. We can imagine the current flowing round the circuit as indicated by the small arrow heads. The battery sets up a steady flow of current round the circuit, including the resistance of the microphone and the primary winding of the transformer. Due to the variations in pressure of the diaphragm of the microphone the electrical resistance of the latter is varied, thus causing the current also to fluctuate.

This fluctuating current passing round the primary of the transformer is reproduced in the secondary, but is stepped up in voltage. The actual ratio of the transformer used depends upon the type of microphone and the first valve of the amplifier to some extent. Frequently a ratio of 13 to 1 is employed, but the recommendation of the company supplying the microphone should be adopted, although a little experimental work in this connection usually repays. From the secondary of the transformer the wires run to the input terminals of the amplifier. With the internal connections of the amplifier we are not concerned, and so pass to the output terminals shown to the right, and to the output

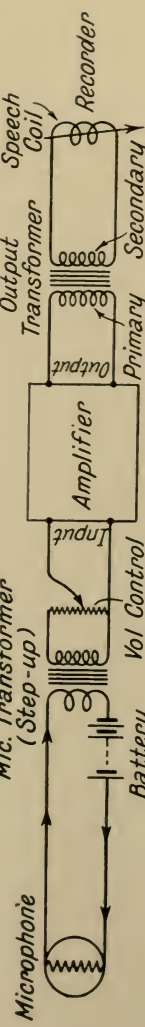


Fig. 11. Electrical Recording Circuit

transformer primary and secondary. From the latter the current flows round the speech coil of the recorder which corresponds to the speech coil already mentioned in Fig. 9 in Chapter I.

What is the object of the transformers? Why cannot we run direct from the microphone into the amplifier, and direct from the amplifier into the speech coil of the recorder?

The object of the microphone transformer is twofold. The battery flowing through the microphone cannot be passed directly through the amplifier. By using a transformer the battery current is kept to one side and transmits only the fluctuations to the amplifier.

The second function of the microphone transformer is to raise the voltage of the fluctuations generated by the microphone to such a level that they will be sufficient to work the first valve of the amplifier.

As is well known the fluctuations or voltage variations applied to a valve must be of such a value that the maximum "swings" the valve to operate at its maximum output consistent with linear amplification. Valves vary in this respect and thus so should transformers. However, the type of amplifier used for home recording is likely to have an input valve of a type commonly associated with "detectors" of radio sets, and for this the "swing" is roughly constant. The use of the output transformer is necessary for similar reasons. From the output terminals of most amplifiers we have a complex current consisting of a direct current (the HT supply), and magnified fluctuations the counterpart of those applied at the input. It is not advisable for the direct current to pass through the fine windings (the wire is sometimes only ·001 in. diameter) of the speech coil of the recorder or pick-up. Quite possibly if a powerful amplifier were used and put direct to the speech coil it would be burned out. Again, better recording is achieved when the direct current is kept from the speech coil.

A point to be mentioned here is that the output transformers usually employed with low impedance moving coil loud speakers are not suitable for use with home recording. Output transformers for moving coil speakers are of the step-down variety, often in a ratio of 40 to 1. For home

recording we do not require this step down, and so a transformer of the order 1 to 1 will frequently be found satisfactory.

Actually these components, the output transformer and the speech coil of the recorder, should be properly "matched" in impedance. It is not within the present scope to deal with impedance matching, and in the experience of the writer trial is the only certain method of obtaining best results.

If we propose building a home recording set by purchasing units in distinction to simply taking the complete outfit from one of the manufacturers given later in the book, one or two points must be borne in mind. First of all the supplier of the microphone will be able to suggest the best ratio of transformer and almost certainly supply it. In the same way the company supplying the recording arm will be able to suggest the best output transformer if the type of amplifier to be used is mentioned.

Connection to Radio Sets. Most modern radio sets, especially of the mains variety, possess terminals labelled "pick-up" and "loud speaker." In this case the secondary of the microphone transformer should be connected direct to the pick-up terminals, and the switch on the radio set should be turned to "gramophone."

The terminals labelled "loud speaker" must be treated more carefully. If the set itself contains a loud speaker this is best disconnected. It must then be determined whether or no the loud speaker is of the moving coil or moving iron type. If the former, a further inspection should be made to determine whether the loud speaker output transformer is also disconnected by removing these connections. Nearly always this is the case, and the output transformer will be found attached to the cone basket of the loud speaker itself.

If, then, the radio set possesses a moving coil loud speaker with associated output transformer, the leads can be removed and in their place fitted the primary leads of the recorder output transformer, as in Fig. 11. With the circuit thus made up we are in a position to proceed with recording.

If, however, the loud speaker is of the moving iron class

we can possibly dispense with the use of an output transformer. The resistance of the speech coil of the loud speaker should first be ascertained. Usually this will be of a similar order to that of the speech coil of the recorder, say, 2,000 ohms. For the purpose of comparison it may be stated that the speech coil of the ordinary moving coil loud speaker is usually of the order of 10 ohms.

Even with sets supplying moving iron loud speakers an output transformer will usually be found advantageous. A good plan in adopting a transformer is to make an arrangement with a radio dealer to obtain the loan of one for trial and then try a few experiments with those having slightly different ratios.

If the radio set does not possess "pick-up terminals" we must proceed a little more carefully.

The input leads from the secondary of the microphone transformer will usually be applied to what is known as the "detector valve" of the radio set. A detector valve used in radio works under different conditions to those required for amplification. The detector valve is operating at little or no grid bias. For amplification purposes we require a negative grid bias depending upon the type of valve which can be determined by reference to the data slips supplied by the manufacturers. Frequently it is of the order of one and a half volts.

The best means of making connections to a radio set is to obtain what is known as a pick-up adaptor. This consists of a device which is plugged into the valve holder of the detector valve. It has three pins, the fourth is omitted, and in the normal way couples aerial tuning circuit to the grid of the valve.

A negative bias may be applied to the grid of the detector valve, as in Fig. 12, where are seen the microphone and its battery and transformer. The secondary of the input transformer has one lead connected to the grid of the detector valve, and the other passes through a grid bias battery having its positive terminal connected to the negative "LT" supply or earth.

All this can be accomplished simply by the use of the adaptor such as is shown to the right of Fig. 12. The various

connections will be found marked on the adaptor. One transformer lead goes to the grid and is made to the connection above the omitted pin, and the other goes via the grid bias battery to the negative "LT" terminal on the adaptor. When the valve is plugged in, connections will be made throughout.

In superheterodyne radio sets using two detector valves connection is made to the second in order from the aerial

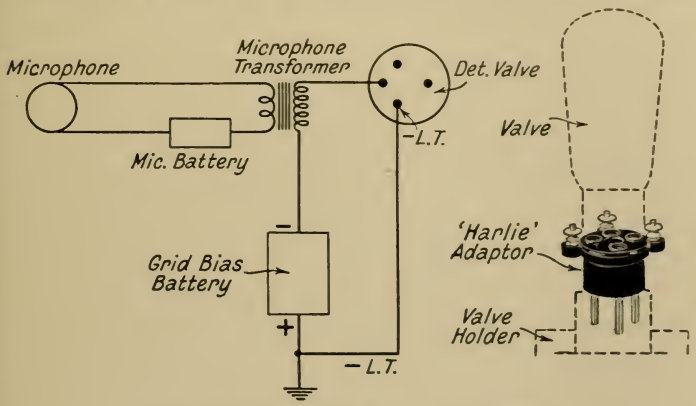


Fig. 12. Connection to Radio Set

circuit. It is best to obtain the manufacturers recommendations for connections as these sets are somewhat complicated.

Recording from Radio. Our description so far has been associated with recording direct from natural sound, that is to say, music or speech which is picked up by the microphone and then passed to the amplifier. It is obviously possible in a similar manner to record from radio programmes. In this case we can completely forget the input side of the amplifier, since this is provided for by our aerial and tuning coils. The connections to be made to the output side of the amplifier are precisely the same as those already dealt with in the case of the microphone.

In home recording equipments attachments are often provided whereby a change of connections from microphone

to radio set, and from recorder to pick-up can be made without disconnecting wires. Obviously the various connections shown in Figs. 11 and 12 can be combined in suitable switches. The equipments vary so much, however, that these can only be worked out definitely with the amplifier, etc., to hand.

In concluding this chapter it must be pointed out that our treatment is far from complete, and gives only those details necessary for the working of electric recording. Once more it is emphasized that in the choice of transformers trial is the only method of obtaining the best results. It can, however, be to a large extent reduced if advice is sought of manufacturers supplying the other items. Of course, if a recording outfit is purchased complete, instructions given should be followed in every detail. Generally speaking, it will be found that all electric home recording sets supply the microphone with its associated transformer, but many omit the output transformer. If satisfactory results are obtained by coupling the recording head or pick-up direct to the output of the amplifier, then nothing further need be said on the matter, though a transformer usually makes an improvement.

CHAPTER III

HOME RECORDING EQUIPMENT

As mentioned in Chapter I, there are two main classes into which home recording equipment can be divided. First there is the class employing an aluminium alloy disc which usually has a plain surface, i.e. devoid of grooves. The recorded groove has to be a long spiral, and to obtain this we must gradually move the recording head inwards by means of a lead screw or similar device, such as was shown in Fig. 8.

For this type of recording disc, therefore, the equipment, apart from its actual recording side, either electrical or acoustic, has to fulfil the following points—

1. The point of the recording cutter or stylus must be held firmly against the surface of the record blank with a pressure sufficient to cut a groove of suitable depth while the turntable rotates. This pressure must, however, be floating and not positive, since no turntables nor record blanks run perfectly true.

2. The recorder head must be fed inwards to produce a spiral.

The second system is that which employs pre-grooved discs. In this case the record before we start recording already has a spiral, but a plain one free from recording and which if placed upon a gramophone would produce no sound except possibly a slight surface hiss. To investigate further refer to Fig. 13, where at *A* we see plain spiral grooves as might appear on the record blank before recording, while after recording they might appear as in *B*, where the recording stylus has cut its wavy path.

In the case of this class of equipment it is obvious that the main mechanical problem has been solved, leaving only that of applying the recording stylus in a suitable position with the proper weight. Traverse inwards takes place automatically, since the cutter rests in a spiral.

The discs employed for pre-grooved work are usually of a material resembling celluloid, and undoubtedly the best known are those produced by the R.C.A. Victor Company. These are manufactured from a special type of synthetic resin, are non-inflammable, strong, and not affected by weather conditions. Besides this they possess a long playing life which normally is not associated with ordinary celluloid records.

Equipments for Plain Discs. Fig. 14 shows the mechanical side of the home recording equipment of Messrs. Harlie

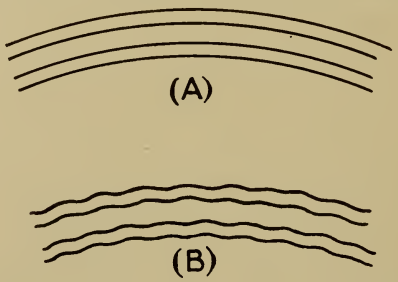


FIG. 13. PRINCIPLE OF PRE-GROOVED RECORDING

Brothers. The action is simple and the construction robust. This system closely resembles the elementary illustration in Fig. 8.

The equipment is easily set up on an ordinary gramophone. First the stand is screwed to the motor board of the gramophone at a suitable distance, so that the driving plate falls immediately above the projecting turntable spindle.

The weight of the recording cutter is applied by suitably pivoting the recording head or pick-up, and the traverse is applied by means of the lead screw which is driven from the centre by means of spiral gears.

Since most gramophone turntables are "dished" downwards a firm foundation is required for carrying the recording disc. This carrier disc is shown in the illustration, and above it is placed the record blank. The whole of the recording arm pivoted on the stand is then swung over the turntable and clamped in position.

The driving plate adhering to the turntable by friction revolves turning the gears, and thus the lead screw which, working against the nut of the recording head, gradually draws it inwards, cutting the spiral. In the meantime the electrical impulses acting upon the recording stylus trace out the modulations.

The Ekco Radiocorder. Fig. 15 at *A* shows the general arrangement of the Ekco Radiocorder, which was originally

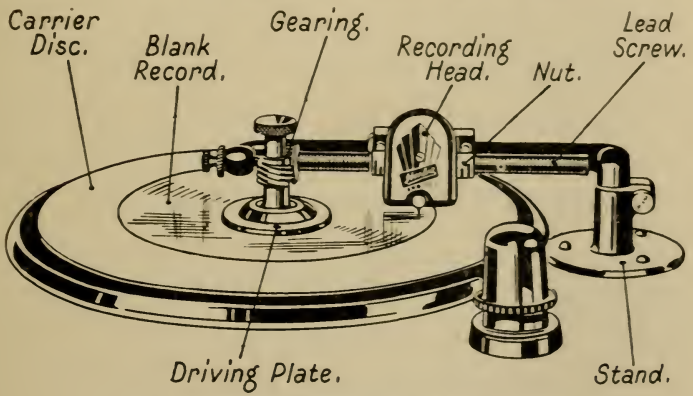
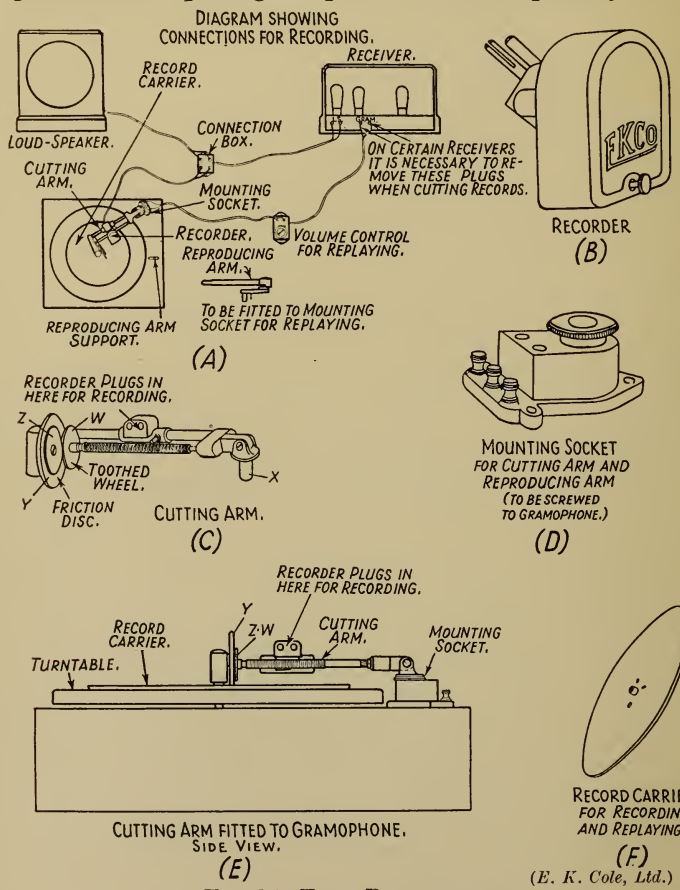


FIG. 14. HARLIE RECORDING ATTACHMENT

developed for recording and reproducing radio programmes. Naturally, however, a microphone attachment can be supplied which renders it suitable for original sound recording. The system shown at *A* is complete for recording radio programmes. At the top left corner of the diagram we find the loud speaker and at the top right hand the radio receiver, and at the bottom the lay-out of the gramophone turntable. The recorder and cutting arm are detachable, and into their place can be fitted the reproducing arm, as shown in the small figure. This reproducing arm is so constructed that it accommodates the recorder for reproduction.

The connection box is, as its name indicates, merely a convenient means of joining up leads. The volume control is an addition for replaying records already cut. This is unnecessary if a radiogram is used, however in the diagram

it is assumed that an ordinary radio set is being used together with a plain gramophone turntable, possibly from



(*E. K. Cole, Ltd.*)

FIG. 15. EKCO RADIOCORDER

an ordinary acoustic machine, and volume control in the pick-up leads is then necessary. For recording a volume control is not always employed.

In the same figure are further details of this system. At

B we have the recorder itself which is a conventional type of pick-up except that its rear is provided with pins to plug into the cutting arm which is shown at *C*. This system also employs a screw after the style of Messrs. Harlie Brothers, but driving does not take place through spiral gears. The plug marked *X* in illustration *C* fits into the mounted socket at *D* which acts as a bearing both for the cutting arm and for the reproducing arm. The recorder plugs into the sockets indicated in *C*.

In the same illustration *E* is a side view of the whole arrangement fitted to a gramophone with the recorder removed for the sake of clearness. It will be seen that the weight to be applied to the cutting stylus is obtained by pivoting in a similar manner to the apparatus of Messrs. Harlie Brothers. The turning of the screw in this case is caused by wheel *Y* in drawings *C* and *E* being driven by the top of the recording disc. Thus wheel *Y* fits direct to a toothed wheel *Z* which gears with another toothed wheel *W* connected directly to the lead screw. Thus as the record blank rotates so does the friction disc, the toothed wheels and the lead screw which traverses the recording head in the manner desired.

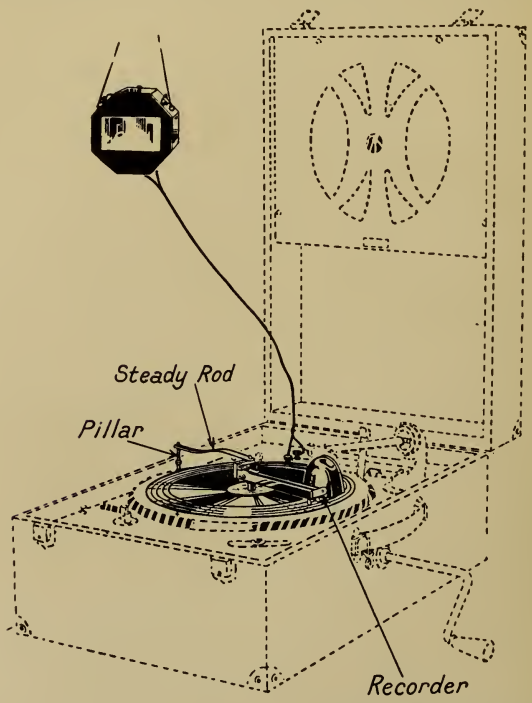
The record carrier disc at *F* is for providing a flat face, and possesses three driving pins which fit into corresponding slots in the aluminium blanks.

Record blanks are of the aluminium alloy variety, and are supplied in diameters of $6\frac{1}{2}$ and 8 in. For replaying aluminium records fibre or thorn type needles must be used. An attempt to employ ordinary steel needles will result simply in the destruction of the record. Fibre needles can be resharpened, and in the Ekco Radiocorder such a device is included.

The microphone which is supplied as additional to the normal Radiocorder is provided with its own transformer, and can be coupled direct in the manner described in the previous chapter.

The Cairmor Recorder. Fig. 16 shows the Cairmor home recording attachment of Messrs. Cairns & Morrison fitted to a gramophone turntable. The general principle is similar to the two systems previously described, although we find a

mechanical variation in that the recording arm is, as it were, balanced across the centre of the turntable. It is held floating in this position by means of a steady rod and pillar. The



(Cairns & Morrison, Ltd.)

FIG. 16. CAIRMOR RECORDER

transverse inwards of the recorder is again effected by a lead screw running to the centre where suitable gearing is provided.

The Kingston-Wearite Recorder. The Kingston-Wearite recorder, illustrated in Fig. 17, operates on an entirely different mechanical principle from those previously described. At *A* we see a general view of the attachment fitted to the motor board of a gramophone, while at *B* we have a

side view showing more details. It will be seen that the recording arm in this case has no attachment to the centre of the turntable, but resembles the ordinary pick-up of an electric gramophone.

In previous examples we have noted that a carrier disc was employed chiefly in order to ensure a flat surface for

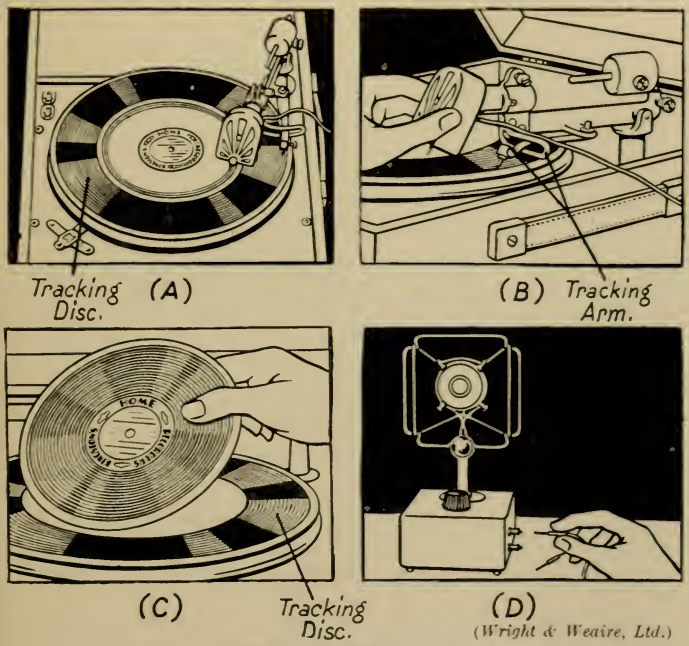


FIG. 17. KINGSTON-WEARITE RECORDER

the record blank. In the case of the Kingston-Wearite system instead of a carrier disc a tracking disc is used. This will be seen in illustrations *A* and *C* of Fig. 17.

The tracking disc has a space in the middle for carrying the ordinary type of blank aluminium disc. To the outside, however, is a spiral having the same pitch as an ordinary gramophone record but free from all recording. In other words, the track closely resembles those in *A*, Fig. 13.

Looking now at illustration *B* we find that the tracking arm is an extension from the cutting arm, and takes the form of a needle holder.

The action of the apparatus is simple. A special recording needle is placed in the recording head, and a thorn type needle in the grip at the end of the tracking arm. In operating the recording needle is placed near the outside of the recording disc, and the tracking arm carrying the thorn needle at the outside edge of the tracking disc. This tracking arm is carried by a spring, so that the necessary weight on the cutting needle is not affected.

The tracking point is gradually forced inwards, due to the spiral on the tracking disc, and carries with it the whole of cutting arm.

To the rear of the cutting or recording arm is a weight which is turned upwards and is adjustable. In the position shown in *B* it is set for recording, while for reproducing it is thrown backwards to relieve the pressure on the needle. At *D* is a table type microphone used with the equipment.

Jennings Acoustic Recorder. So far we have chosen our examples from electric recording, but it is obvious that each of these could be made to serve acoustic recording merely by replacing the electric recorder or pick-up by a sound box to which was coupled a horn.

In Fig. 18 is shown an acoustic recording attachment with Mr. S. A. Jennings who invented the device in 1916. An examination of the illustration indicates that the arrangement is similar in general principle to the Kingston-Wearite system just described. In this case, however, tracking takes place by means of an arm to the inner diameter of the record and not the outer. Furthermore, in the case of the Kingston-Wearite system a special tracking disc was used, but here it being found that modulation has no affect on the results, an ordinary gramophone record was used.

Actually the principle has a theoretical advantage over the Kingston-Wearite system in so far as a greater linear speed of recording is achieved. This is likely, however, to be offset owing to the greater drag that the cutting stylus will impose upon the disc, and thus to the motor.

It will be noted in the illustration that the horn is attached

directly to the back of the sound box, and is of light construction so that undue weight is avoided.

The Sheldon-Wilkinson Company, with whom Mr. S. A. Jennings is associated, also provide a complete range of electrical recording equipment, which is described in Chapter IX in connection with the making of talking pictures. To those interested only in the sound side of recording,

(*Mrs. Sheldon-Wilkinson*)

FIG. 18. JENNINGS ACOUSTIC RECORDER

equipment is available without fitments for connecting to camera or projector.

The Pam-O-Graph. In America home recording has developed to a greater extent than in Great Britain, probably owing to the fact that the equipments placed upon the market were of more expensive construction than those first started in this country. Cheap home recording equipments, while they possess novelty for the time being, soon become neglected playthings, and condemn what can be a fascinating as well as a useful hobby.

The Pam-O-Graph, a product of the Sampson Electric Co., of Canton, Mass., and handled in this country by Messrs. Claude Lyons, Ltd., is a complete electrical apparatus designed specifically for the purpose of recording on plain aluminium discs. It is not an attachment to nor an adaption of any existing apparatus, but each detail has been worked out with a view to producing the best results on the recording medium adopted.

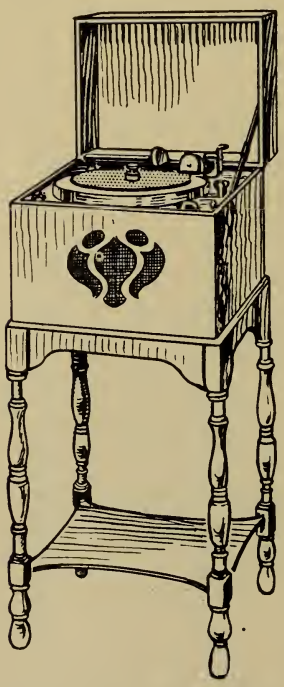


Fig. 19. The Pam-O-Graph

Fig. 19 shows a general view of the equipment housed in the usual American type of walnut cabinet. As will be noted, both a recording and a reproducing head are provided, together with a loud speaker. The traverse is accomplished by internal gearing which eliminates the necessity for overhanging lead screws and such-like which while they work quite efficiently do not make for ease of operation. Of course, where attachments for home recording have to be made on existing gramophone turntables, the equipment of necessity must be such that it can easily be fixed, and in this case some lead screw device which overhangs the turntable is unavoidable.

The discs used on the Pam-O-Graph vary in size from 6 in. to 12 in. Incidentally the playing time of these is as given below—

6 in.	1¾ min.
7½ in.	2 min.
10 in.	3¾ min.
12 in.	5 min.

One of the unique features of the Pam-O-Graph is a device

for indicating when the sound applied to the microphone is just sufficient to produce good recording. In most equipments the proper recording level has to be determined more or less by trial and error.

In the Pam-O-Graph this is accomplished by means of a Neon light which in ordinary vocal recording should glow at the peak of the voice. If no glow appears the sound is insufficient, while if the glow entirely covers the bulb sound is too loud. Actually the proper level of recording is indicated by a sort of flickering action.

The Sampson Electric Co. are pressing this apparatus for

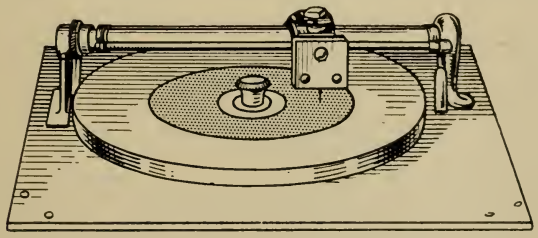


Fig. 20. Trugraph Recorder

business and for educational purposes, thus bringing a rival into the field of dictating machines.

The Trugraph Recorder. The Trugraph recorder, a product of the Astatic Microphone Laboratory of Youngstown, U.S.A., is another American recorder employing plain aluminium discs. Again, the apparatus has been designed specifically for the work.

Fig. 20 shows the general arrangement of the motor board, where it will be noted that the recording head is traversed across the disc by a lead screw which is held firmly at both sides of the turntable, and not pivoted in the middle as is the case with most British machines. A special clamp is provided for holding down the record blank. The usual type of carrier disc is not employed in this machine, since the turntable is made flat.

A particular feature of the Trugraph recorder is that it employs what is known as a "crystal" recording head, which was developed for recording on metal, and operates on

somewhat different principles from the usual type of pick-up. Recorders are available for operating at speeds of 78 and $33\frac{1}{3}$ r.p.m. The use of $33\frac{1}{3}$ record will be more apparent in the second part of this book, when we are dealing with motion pictures. An obvious advantage which may be remarked upon here is that the time of playing will be considerably longer than in the case of the ordinary records of 78 r.p.m.

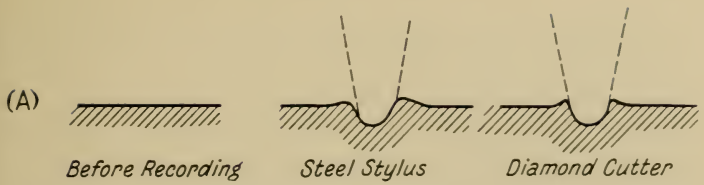
The company dealing with this apparatus have also produced a crystal microphone which employs a Piezo-Astatic element made from crystals grown from Rochelle salts coupled to a tightly stretched duralumin diaphragm.

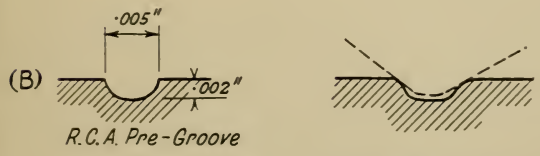
One of the advantages of this type of microphone is that it can be connected directly into an amplifier without the medium of a transformer. Furthermore, no microphone batteries are employed, since it is self-generating. It is stated that this type of microphone is capable of handling frequencies up to 8,000 cycles.

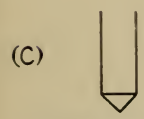
Pre-grooved Records. The recent revival of interest in America in home recording undoubtedly owes much to the introduction by the R.C.A. Victor Co., of the special synthetic resin pre-grooved record. As mentioned previously, recording by means of pre-grooved aluminium or other metal discs has been tried, but with no marked success, the chief trouble being surface noise or scratch. It is safe to say, when speaking of pre-grooved records reference is made to those of a non-metallic character. In the early days celluloid was employed, but it is by no means so satisfactory as the new synthetic material of the R.C.A. Victor Co.

In recording on pre-grooved records the greater portion of the success depends upon the record itself, and not so much upon the recording mechanism, although naturally this also must be of high quality.

The recording action in a pre-grooved record is entirely different from that where we are cutting upon a plain surface. In Fig. 21 we find illustrated diagrammatically at *A* the action taking place in the plain metallic type of record during recording. First we have the plain surface which is cut or scribed by the recording point into the type of groove shown in the right-hand illustrations. Sometimes the







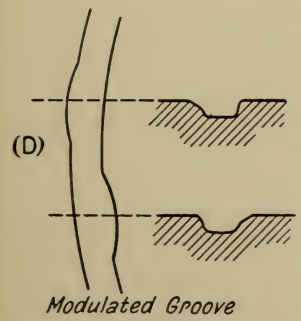


FIG. 21. PRE-GROOVED RECORDING

recording cutter or stylus consists simply of a plain steel needle having usually a point with an angle more obtuse than that of an ordinary gramophone needle. Although it is usually termed the "cutting" needle no true cutting action takes place, it being more fully likened to the scribing action encountered in ordinary workshop use. The needle marks or pushes away the aluminium surface of the disc, and leaves it as in the middle illustration of *A*. On the other hand, some recording outfits employ a diamond cutter, which certainly does cut, but leaves a groove after the style shown to the right of *A*. No humped ridges are left at the top of the record as in the case of the steel recording needle, but instead there is a sharp burr. The fact to be emphasized is that reproduction or playback

takes place by the needle entering the groove and resting on its bottom, as will be gathered by the dotted lines shown in the figures.

Looking now at *B* we find in the left-hand figure the approximate dimensions of the R.C.A. Victor pre-groove record. This should be compared with the dimensions of the standard gramophone record as already given in Fig. 6.

The needle employed for recording has a very obtuse point, as shown in illustration *C*, in fact, examining it casually one would wonder how it could possibly be used for recording or playback, since it is totally unlike the ordinary gramophone needle.

Actually when the point of this needle acts on the groove considerable pressure is exerted on the edges which owing to the rotation of the disc are embossed or pressed down something after the style shown in the illustration at the right of *B*. Thus it is that recording takes place on the upper edges of the groove, and not the bottom which remains a true spiral. The action will be gathered by examining the illustration *D* taken across the section of recorded groove showing exactly how recording is effected.

Looking at the matter from a theoretical aspect, it would be imagined that the process is by no means so perfect as where cutting or scribing is effected straight into a plain disc. In the experience of the writer, however, the pre-grooved R.C.A. Victor discs give, in general, considerably better results than those of plain aluminium. Furthermore, they possess another advantage in that the needle used for recording is also employed for playback. It is not so much the fact that the same needle is used as that it is of metal. Fibre needles, athough they give pleasing reproduction, are apt to break away or wear at the point under service. Although this may not be very disastrous from the point of view of ordinary recording when we are dealing with talking pictures on the disc system as described in Chapter IX, the results are fatal.

The Pacent Recordovox. The Pacent Recordovox is one of the best known equipments for utilizing the pre-grooved disc. The illustration in Fig. 22 shows that the apparatus is simple, and consists of a standard type of Pacent pick-up

suitably provided with extra weights which are carried above the reproducer as indicated by the dotted lines.

The remainder of the equipment consists of a control box with leads and adapters and hand microphone. The control box is a junction for the various connections, and at the same time enables spoken voice or radio programmes to be recorded either separately or together. Thus one may

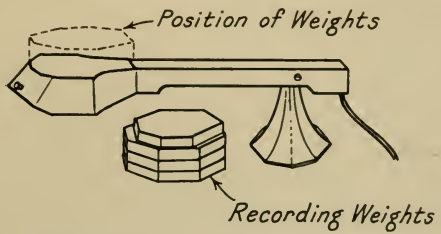


Fig. 22. Pacent Recordovox

easily record direct voice with music taken from a radio programme as a background.

A number of weights are supplied with each Recordovox unit. The correct number to be used in recording is dependent upon the type and characteristics of the sound as well as the recording medium. Thus, since low notes cause greatest sideways swing of the recording point there will be more tendency for the recording needle to jump. Thus it is reasonable to suppose that more weight would have to be provided. In reproducing all that is necessary to do is to remove the extra weight and use the pick-up in the normal manner.

Dictating Machines. The present chapter would not be complete without reference to dictating machines which have carried on the work of home recording since the early days of Edison and the phonograph. In principal the dictating machine of to-day as exemplified by the Dictaphone, one of the most popular makes, is similar to the original phonograph employing wax cylinders. In mechanical construction, however, and in method of working the Dictaphone is quite a different proposition. An enormous amount of ingenuity has been displayed in making the processes of

recording and reproduction as simple and fool-proof as possible. Wax cylinders are used and it might be thought that it would be a delicate operation to handle these without damage. As a matter of fact the whole process is simple,

FIG. 23. THE DICTAPHONE "DICTATOR"

and the construction of the Dictaphone is far more sound than a good many modern automobiles.

Fig. 23 shows two of the principal units of the Dictaphone, the first one being what is known as the "Dictator," and the second the "Transcriber." The Dictator is the machine

employed by the person wishing to record speech, while the Transcriber is employed by the stenographer or dictaphonist who types from the recorded speech.

The Dictaphone is, of course, an acoustic machine, and instead of using a large trumpet or horn, as shown in Fig. 18, a small mouthpiece is employed connected to the sound

FIG. 23A. THE DICTAPHONE "TRANSCRIBER"

box by means of a flexible pipe. It is thus easy and convenient to record at some distance from the machine and without keeping the body in a rigid position.

The sound box itself employs a sapphire cutter, and is of unique design. Actually it contains two distinct points, first, the cutter which records by the hill and dale system, and second, a rounded playback which can be brought into action simply by moving a lever. It is possible to dictate on the machine and then merely by pressing this key and sliding the carriage backwards, immediately to hear what was recorded.

A further feature is the release button situated on the mouthpiece. The cylinder revolves only when this button is depressed. Thus when using the machine one depresses the

knob just before one speaks, releasing it immediately a sentence is complete. This effects considerable economy in length of recording cylinder.

The transcriber is a similar machine except that it is not provided with a recording device, but instead is equipped with a pair of "headphones" which operate on acoustic principles.

An ingenious arrangement for starting and stopping, and repeating is provided by means of which the typist works the machine by the foot, thus keeping her hands and fingers free for the keyboard of the typewriter.

Attempts have been made from time to time to adapt the disc type machine for business purposes. It is possible, of course, that the disc machine might enter this field successfully, but it would have to be considerably improved. At the outside a 12-in. disc record lasts five minutes, while a Dictaphone cylinder runs for eleven minutes. Furthermore, considerable difficulties would have to be overcome before a disc machine was rendered as foolproof and easy to operate as the Dictaphone.

It should be mentioned in conclusion that dictating machines are intended to record and reproduce *clear* and not necessarily natural speech. There is a vast difference in this, as will have been gathered by the references made in Chapter I. A dictating machine under normal conditions would not be suitable for entertainment or for recording music, although we believe certain experiments have been made by the gramophone companies along these lines.

One of the great economies of the dictating machines utilizing the wax cylinder is, that after a cylinder has been transcribed the cylinder itself is placed on another machine known as a "shaver," which by use of a sapphire cutter skims away the recording by taking a cut of a few thousandths of an inch, and leaving a polished surface ready for the next dictating. A cylinder will thus last for many dictations, and when one considers that it is possible to dictate some 1,400 words per recording the total life of even a single cylinder will be appreciated. It is actually in the region of 140,000 words.

CHAPTER IV

RECORDING NOTES

The first thing to fix in mind with regard to the procedure of home recording is that perfectly satisfactory records *can* be made. This statement may seem somewhat extraordinary, but, consider the parallel case of the camera. How many people having no previous experience in photography would take a camera and produce excellent results straight away? Certainly this *might* be done with the modern trouble-free systems, but even with these first attempts are likely to be disastrous. But the purchaser of a camera does not despair because he or she knows that other people experience no trouble and that photography in general has been accepted. With home recording it is different, since it has not yet attained the popularity of the camera. The first attempts at home recording are likely to be disappointing unless one is either exceptionally fortunate or has expended a considerable sum in obtaining first-class equipment. By this we do not infer that good results can be obtained only by the expenditure of a large amount of cash. What we do say, however, is that with most of the cheaper recording equipments a certain amount of experimental work must be done at first.

Choice of Equipment. The amateur contemplating home recording is faced with a fairly wide market in the choice of equipment, and one which incidentally is widening as more and more firms develop apparatus. What is the best type of equipment to purchase?

In the first place one's requirements must be decided. If one merely wishes to obtain a novelty for use at parties then one of the cheaper type of attachments will serve admirably. For a few shillings an attachment may be had which will fit to a portable gramophone, and with care will produce reasonable results. But for serious work in which an endeavour is made to equal the quality of standard

gramophone records a more elaborate type of apparatus is necessary.

The inevitable optimism of advertising always forces companies to state that their home recording equipment enables any one to produce records equal in quality to those of gramophone records. Straight away it may be said that no home recording, in the experience of the writer at all events, can be said to equal the best gramophone records. In case this statement is discouraging we may further remark that nevertheless with suitable equipment, due care, and some little experience, really excellent results may be obtained. In fairness, however, it cannot be expected that we, with an equipment costing at the most a few pounds, can produce results equivalent to those obtained by the gramophone companies with their elaborate studios and equipment and the accumulated recording experience of years.

With regard to the system adopted for recording there are, roughly speaking, two choices, the plain aluminium disc and the pre-grooved resin type. Again, in the opinion of the writer, the pre-grooved record can be relied upon to give the more uniform results with less trouble. Nevertheless, excellent work can be done on aluminium discs which, at the time of writing, possess the advantage insomuch as they are easily obtainable in Great Britain, whereas the pre-grooved R.C.A. Victor home recording disc has only recently been introduced.

It is naturally a somewhat difficult matter to advise as to what type of recording equipment to purchase. Like most other manufactured articles there are categories of good, bad, and indifferent. Much still depends upon the purchaser. Speaking from a personal viewpoint we must express preference for those home recording equipments which are constructed on general engineering principles, and do not owe their being to ingenuity. The Reylik home recorder shown in Fig. 83 in the second part of this book has been found very useful by a number of amateurs both in the home recording and home talking picture fields. The equipment itself possesses some distinct points of use to the amateur who wishes to experiment. The tracking

device is set aside from the turntable and can, if necessary, be modified to suit any requirements. We do not particularly like the removable centre pulley which operates from the top side of the disc, but it lends itself to modification, or adjustment.

Some amateurs may feel inclined to construct their own equipment, and this in the opinion of the writer is a sound procedure, providing one is prepared to spend a little time and money in experimental work.

The first essential in building a disc recording system to operate on the plain aluminium recording disc is to obtain a tracking device. This can usually be bought from one of the equipment dealers or, if you happen to be mechanically minded, can be constructed especially if you possess a small lathe. In actual fact the requirements of a tracking device are simple. A lead screw of some type must be employed, and this must traverse the pick-up or recording head across the disc a distance of approximately one hundredth of an inch per turntable revolution. By this we mean that the grooves are spaced about one hundredth of an inch apart. The Reylik design is particularly adaptable, since by simply changing the size of the driving pulleys a different pitch in recording grooves can be obtained.

Inwards or Outwards ? The modern gramophone record plays from the outer diameter to the inner, but this is no reason why we should adopt the principle for home recording. As a matter of fact this feature of the modern gramophone record is a mistake, and it would be far better if the records were played from the inner to the outer diameters. This was actually appreciated some years ago when records for talking picture work were produced—which work from the inner to the outer diameter.

The reason for this is that near the centre of the record the sound waves are more closely "packed" than at the outer diameter where the linear speed is higher. During the playing of a record the needle point wears considerably —far more than most people imagine when they use a single needle for playing half a dozen records. A trained ear can frequently detect the loss of needle point after the playing of a single record.

The playing should start at the middle and thus give the closely packed recording the benefit of a sharp needle point. This is particularly the case with home recording, where with aluminium discs thorn type or fibre needles are usually employed. Whatever may be said about these needles from the tonal point of view they are inclined to give trouble when used on the aluminium discs. If, however, recording takes place from the middle of the record outwards it is found that the needles give far better service. Played in the ordinary manner it is a fairly frequent occurrence to find that the point of the needle is damaged, and "repeats" occur when nearing the middle. Probably this would not happen with a 6-in. record, but for serious home recording work 10-in. records are more or less a necessity.

In choosing a recording equipment, therefore, it is advisable to note whether it is possible to change the direction of the tracking device. Usually this is a fairly simple matter. In the case of the Reylik traverse outwards has already been adopted. The necessity of working from the inner diameter to the outer is particularly apparent when one is concerned with home talking picture work as described in Chapter IX in the second part of this book.

The Motor. Since most home recording equipments are in the form of an attachment the motor is determined by what gramophone is used. Which is the better, spring or electric motor? There is no doubt that a spring motor is likely to be something of annoyance by running down just at those times when you require its services. This, of course, scarcely counts as an objection, but merely points the need for systematic routine in recording. A really good spring motor properly governed is hard to beat by any of the electric motors at present on the market. If you contemplate a portable equipment then probably a spring motor will be pressed into service unless you are a car owner, when a suitable electric motor can be obtained for running from accumulators. In making the purchase of a spring motor there are several points to be borne in mind. First of all motors are sold under the rough classification of the number of springs they possess which are one, two, and sometimes three, although the last number is uncommon nowadays.

Now the strength of a spring motor does not depend upon the number of springs which merely govern the playing time. For home recording work a two-spring motor should be used, since the single spring does not provide much time margin.

Great care should be taken in selecting a motor for the simple reason that most spring motors are not sufficiently powerful for good home recording. By this we do not mean to say that they will not drive an aluminium disc working under a recording cutter, but simply that more power is wanted for best results. Really, the most satisfactory way is to obtain a good quality two-spring motor and then have its gearing changed so that the motor itself runs faster than usual while still maintaining normal turntable speed of between 78 and 80 r.p.m. This is equivalent to gearing up the motor, and provides more power to the turntable.

On the question of electric motors, there are two common types on the market to-day. The first of these is known as the "Universal," and will run from either A.C. or D.C., and is adjustable for different voltages and frequencies by a sliding resistance. This type obviously possesses the advantage due to its name, but there are one or two points not so entirely satisfactory. First of all, most universal motors are driven by means of a belt, i.e. the motor drives a larger wheel through the medium of a thin band, which is kept taut by means of a jockey pulley or similar arrangement.

From the point of view of home recording, belt slip of any description is disastrous, and naturally, since the pressure exerted by a cutter is much greater than that of an ordinary gramophone needle, there will be greater chance of this happening. In some of the universal motors on the market to-day tensioning of the belt takes place after the idea illustrated at *A* in Fig. 24. In principle this is not always satisfactory, for if the spring tension is increased so also is the pressure on the bearings which tends to slow down the motor. If trouble is experienced with a universal motor of this type it can be cured by altering the arrangement to follow the principle shown in *B* where a small jockey pulley is introduced as shown. This increases the arc of contact of the belt besides tightening.

Care should be taken that the jockey is applied at the tight or driving side of the belt, which will be understood by arrow heads indicating the direction of revolution.

The other electric motors used are known as "induction" types, and these may be divided into two classes. First, there is the induction motor which drives free from gearing, or in other words, the turntable spindle is connected direct to a large rotor which contains numerous poles. The

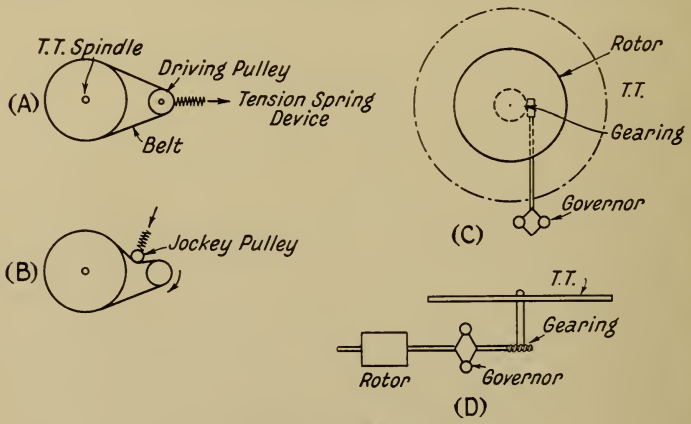


Fig. 24. Electric Motor Drives

induction motor will, of course, work only on alternating current.

In the experience of the present writer, while this type of induction motor can certainly be used for home recording, it does not give entirely satisfactory results because it is slow in starting. The pull on the rotor is direct and the governor is geared up from it, and thus exerts a drag on starting.

The other type of induction motor shown diagrammatically at *D*, Fig. 24, drives from a small rotor through the governors, and by a reducing mechanism to the turntable. This, in the experience of the writer, is more satisfactory from the point of view of home recording, since the rotor runs at a much higher speed, and thus possesses the

advantage of high starting torque. There is an additional advantage in so far as this type of induction motor is usually cheaper than the former.

Do not make the purchase of a cheap and light construction motor of any description, since the more power one has at one's disposal in home recording the greater the likelihood of obtaining first-class results.

The Microphone. For direct recording the microphone is the first step, and it is no exaggeration to say that the quality of the results obtained under normal conditions depends mostly upon it. Roughly speaking, we may say there are three types of microphone at present on the market, the carbon type, which operates owing to the variation of resistance of closely packed carbon particles, the condenser microphone which depends upon the diaphragm forming one plate of a condenser, and lastly, the moving coil microphone which in principle is the converse of the moving coil loud speaker.

For home recording the carbon microphone practically holds the field, although, as we shall mention later, there is no real reason for this.

It is a significant fact that manufacturers of home recording equipment admit that their greatest difficulty lies in obtaining a good microphone at an economical figure. The amateur recorder who considers his subject seriously should bear this in mind. Although generalizations are dangerous, it is safe to say that practically all the recording equipments on the market can be improved considerably by a replacement of their microphone by a better quality article. It is possible to obtain microphones from a few shillings up to, say, £25. Another curious thing about microphones is that in the cheaper qualities they are by no means a uniform product. The writer has used two microphones of precisely the same make and price, and found one really excellent, while the other was practically useless. With more expensive microphones this variation is not likely to be so great.

Another point in relation to microphones is that whereas quite a cheap instrument will reproduce fairly natural voice it requires a much better job to deal with music. This

distinction is so definite that some manufacturers list their microphones as "announcing" apart from general purpose.

Fig. 25 shows several microphones, etc. At *A* is the "S-J" microphone marketed by Messrs. Claude Lyons, which is of the single button type and of 100 ohms resistance. It is stated to handle frequencies from 70 to 3,000 cycles, and is obtainable in three sensitivities, viz. *A* very sensitive, *B* medium (standard), and *C* damped. For general purposes the medium sensitivity is to be preferred. The price of this microphone is 75s. The writer has employed this microphone for a certain amount of recording work and found it quite satisfactory from the point of view of voice, although it will not produce best quality results on music.

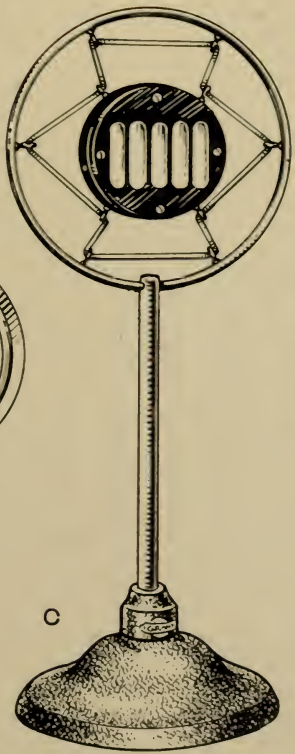
The Amplion microphone shown at *B* is a larger model priced at £5, and is 4 in. in diameter and very strongly constructed. Primarily it is an announcing microphone, but its characteristic is sufficiently good for music. It is not as sensitive as some of the cheaper microphones, but possesses the advantage that it can be handled during recording if necessary, providing care be taken. It is usually operated with a step-up 13 to 1 transformer, and with a polarizing voltage up to 20 volts. In using a microphone of any description the battery voltage is kept to a minimum consistent with good results. A higher voltage tends to give increased loudness of signal, but if too high may damage the microphone.

At *C* we have the Igranic Pentrovol microphone on stand. This is probably one of the finest carbon microphones on the market, and is capable of producing really excellent results. It is listed at £7 7s., but for serious work is really worth the outlay. With it can be supplied a control unit which embodies a series of connections for microphones, battery pick-up if required, amplifier, an ammeter showing the microphone current, and a volume control for regulating.

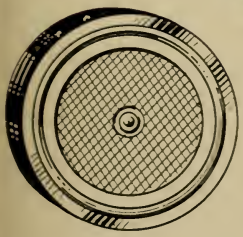
The transformer which should be used with the Pentrovol microphone should have a step-up ratio of 10 to 1 or higher, and a primary winding with an impedance of the order of 1,500 ohms at a frequency of 50 cycles. The energizing

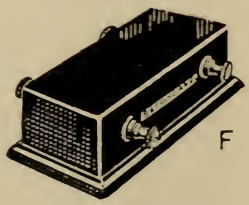
(*Claude Lyons, Ltd.*)

(*C. Fredk. Adolph.*)



(*Igranic Electric Co., Ltd.*)





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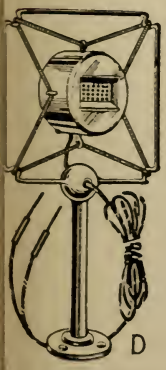

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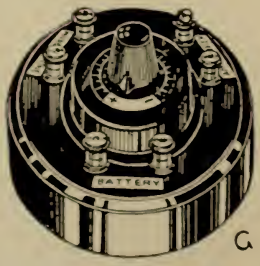


(*C. Fredk. Adolph.*)

FIG. 25. MICROPHONES

A. "S.J." Microphone
B. Amplion Microphone
C. Igranic Pentrovol Microphone on Stand
D and *E*. Adolph Microphones
F. Adolph Microphone Transformer
G. Adolph Microphone Control Unit

current can range from 2 to 20 volts—much the same as for the Amplion microphone previously described. Generally speaking, however, when the microphone is coupled relatively close to the transformer a voltage of 6 will be found satisfactory. As a matter of fact, in using all types of microphone the voltage which should be applied is really immaterial, since it is the flow or current consumption which is really important. In the case of the Pentrovol this should be of the order of 12–15 milliamps., the resistance of the microphone being approximately 300 to 400 ohms. If a long lead has to be employed then naturally the voltage would be higher.

At *D* and *E* are two microphones manufactured by C. Fredk. Adolph & Co., who specialize in work for home recording. They are priced at 25s. and 12s. 6d. respectively, and represent the product adopted by most of the manufactures of home recording equipment. The same company possess many other types of microphone, particularly suited to the needs of the amateur. At *F* is a neat "Adolph" microphone transformer, and at *G* a control unit embodying transformer, connection terminals, and rheostat.

The leads running from the microphone to the transformer should preferably be shielded, or in other words run in either lead-covered cable or metal braided cable. The metallic covering of either of these should be earthed preferably to the earth connection of the amplifier or radio set.

In long distance transmission, and by long distance we imply something in the order of 20 or 30 ft., the leads should be taken direct from the microphone across the distance, and then coupled to the transformer which should be adjacent to the amplifier.

Volume control of the microphone takes place between the secondary of the transformer and the amplifier, as shown in Fig. 26. In using this volume control it should be borne in mind that its object is to modify the recording level according to the requirements of the particular sound being recorded, and is not for keeping the output of the amplifier within distortionless limits. With the microphone volume control set at a maximum the amplifier volume

control should be adjusted so that blasting does not take place, then whatever movement is made to the microphone volume control distortion will not be introduced.

Loud Speaker as Microphone. We have mentioned that the moving coil microphone at present used in America for talking picture work and in this country for the making of gramophone records by the Columbia Graphophone Co., is the converse of the ordinary moving coil loud speaker.

Working from this assumption the writer carried out a series of tests to determine whether or no it was possible to employ an ordinary moving coil loud speaker as a microphone. The results of the tests were satisfactory, and the

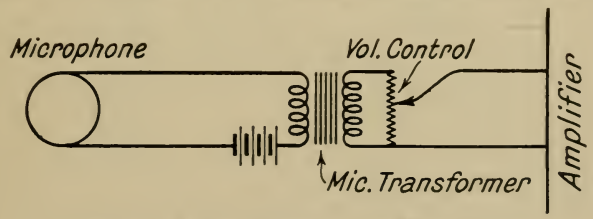


FIG. 26. VOLUME CONTROL OF MICROPHONE

arrangement employed is shown in Fig. 27. To the left we have an ordinary moving coil loud speaker of the permanent magnet class and with a cone diameter of 9 in. The leads from the speech coil are connected to a transformer—having a step-up ratio of the order of 30 to 1 or even higher. As a matter of fact the ordinary output transformer used with the speaker may be employed without making a change to its connections. Normally it is used as a step-down coming from the amplifier to the speech coil. When, however, the fluctuations are produced in the loud speaker and the transformer is connected to the input terminals of the amplifier naturally the transformer acts as a step-up.

It was obvious at the beginning that this arrangement would work, but the doubt was that a two valve amplifier of the ordinary mains type would be sufficient to bring the level suitable for home recording. This was, however, found perfectly satisfactory, and furthermore the recording obtained by using a loud speaker as a microphone in this

manner was superior to any of those obtained with the ordinary type of carbon microphone. Naturally the loud speaker was completely free from packing, howling, and other disadvantages associated with carbon microphones in general.

The idea of this arrangement immediately brings to mind the fact that it would be possible to arrange switches whereby the loud speaker could in the first place be used as a microphone and then for reproduction. A little ingenuity

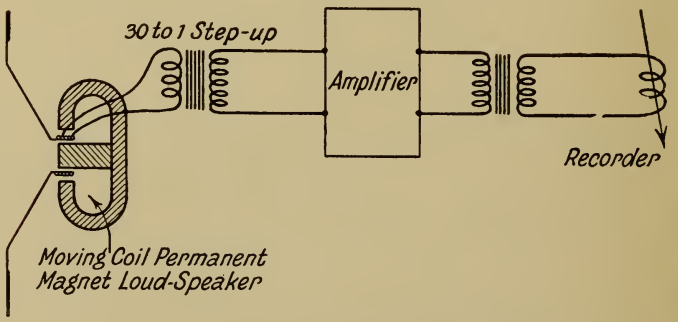


Fig. 27. Loud Speaker as Microphone

will soon solve the switch problem, which depends chiefly upon the arrangement of the connections to the amplifier or radio set. The reader if using a mains-operated amplifier, especially if of a powerful variety, is strongly advised to carry out a little experimental work after this fashion before spending a lot of money on carbon microphones.

Many loud speakers of the moving coil type are energized by a field current, and do not use permanent magnets. This field current causes a certain amount of hum, but some tests carried out by the writer indicate that this is not usually objectionable in recording, especially when rectification takes place by half wave, when the periodicity of the hum is in the region of 50 cycles, which is not recorded upon the disc. In any case, if the hum is objectionable it can usually be reduced by the insertion of chokes and condensers after the ordinary principle of smoothing as adopted in radio and similar work.

The Pick-up or Recording Head. Although most of the present day pick-ups operate on similar principles, and their construction does not widely differ, it is essential for the purpose of home recording that a really substantial instrument be employed. The writer finds that in this country much of the home recording work is being done using "B.T.-H." pick-ups which are certainly satisfactory.

In choosing a pick-up for recording one is concerned also with the method of suspension. Of course, if a complete attachment is purchased direct the pick-up will be included, and there the matter ends, but if one is making a home recording set the method of operating the lead screw enters

Fig. 28. B.T.-H. Pick-up

into the question. Usually this necessitates the use of one of the vertical type of heads, such as is shown at *B*, Fig. 15, of the Ekco Radiocorder. On the contrary, for pre-grooved work a pick-up arm of the style of the Pacent Recordovox in Fig. 22 is obviously most suitable. An English equivalent to this is the B.T.-H. minor shown in Fig. 28.

Again, we must remind the reader that if he or she contemplates home talking picture work where it may be necessary either to record or reproduce from 16-in. discs, the pick-up arm must be long enough to accommodate this diameter. Messrs. Varley supply a very useful pick-up and arm suited to 16-in. disc recording. As a matter of fact this is the instrument employed on the talking picture apparatus of British Talkatomes, and shown in Fig. 51.

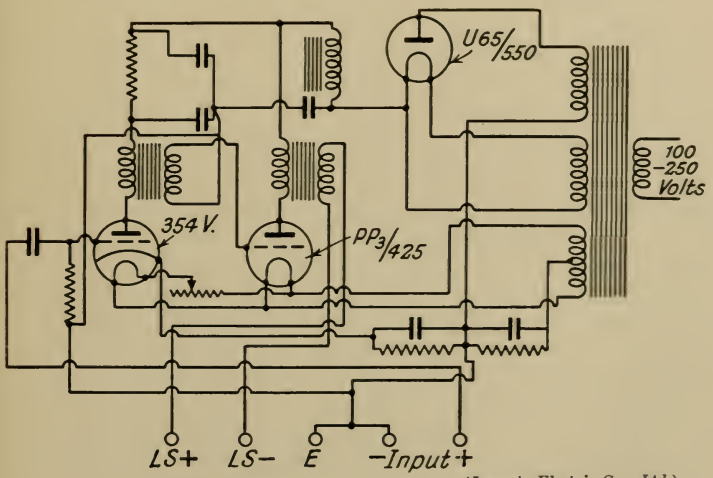
If the type of traverse is such that it moves the pick-up itself across the disc in angular direction then in fitting the apparatus care should be taken that the angular error of the needle is shared. Usually it is sufficient to fit a pick-up and arm so that the needle passes over the centre of the turntable when in the inner position. Other things

(*Igranic Electric Co., Ltd.*)

FIG. 29. P225 AMPLIFIER

being equal, the longer the pick-up arm the better it is for recording or reproduction.

Recording. As mentioned previously recording on the aluminium type of disc usually takes place either by means of a steel needle or a diamond cutter. In the case of the latter nothing further is to be said, but the needle sometimes sold for the former method can be considerably improved



(Igranic Electric Co., Ltd.)

FIG. 29A. CIRCUIT OF P225 AMPLIFIER

by a little experiment. The writer has obtained beneficial results by carefully stoning the point on an oil stone of the type used by carpenters and engineers. Considerable care should be taken, but a little experiment will amply repay the trouble. The point of the needle should be examined by means of a magnifying glass. Sometimes the needles sold for recording purposes when examined in this manner exhibit only too clearly their imperfections.

Amplification. Several times we have mentioned the different types of amplifier that can be used for home recording. Naturally, if one has a good mains-operated radio set one does not care to purchase a special amplifier. Those

wishing to keep an amplifier especially for home recording will find one of the type shown in Fig. 29 very satisfactory. This has an output of some 3 watts, and its circuit diagram is shown on page 61.

Some of the best recording on aluminium discs the writer has heard is that produced by the Marguerite Sound Studios of Shaftesbury Avenue, where records are produced for a nominal figure.

Mr. Watts who has developed the recording system utilizes a very powerful amplifier having, we believe, a wattage of the order of twelve. This enables him to use a heavy pressure on the recording cutter which gives a sound groove of considerable depth. The great advantage of this is that it permits a steel needle for playing back. Those used are of the spear point type usually associated with celluloid records. Ordinary straight needles are likely to damage even deeply grooved aluminium discs. A set is given to the spear pointed needles so that the pressure is somewhat relieved. The seriously minded amateur is advised, if he adopts the aluminium disc, to use an amplifier of as high a power as possible. This may seem like using brute force to get a good job, but it certainly produces the results. For home talking picture work where loss of synchronism due to the reproducing needle is absolutely fatal, any system that will enable a steel needle to be employed is worth adoption.

Recording Notes. Much of the technique of home record making cannot be learned except through the medium of spoiled discs and intelligent experiment. There are, however, a few general principles which may be learned, although in sound recording the exceptional case is always occurring.

Acoustic recording is entirely different in technique from electrical, due chiefly to the limitations imposed by the horn recorder. The great difficulty is to get sufficient sound to the diaphragm of the sound box to operate the cutting needle or stylus. Thus, for instance, in Fig. 30 we see pianoforte recording by the Kingston system, where a portable gramophone is placed upon the piano, with the horn turned backwards so as to take maximum sound vibrations. For

microphone work this position would probably be the worst possible choice, especially if the microphone were of the carbon type. Usually best results from a piano are obtained when the microphone is 5 or 6 ft. distant. Vocal performers can best be placed somewhat closer say, as an average, 3 ft., depending to a certain extent upon the voice strength.

(Wright & Weaire, Ltd.)

FIG. 30. ACOUSTIC RECORDING OF PIANO

Other musical instruments with the exception of the organ are best placed nearer to the microphone than the piano.

One of the best ways to acquire experience rapidly in sound recording is to run off one or two test records. The first should be made to test the efficacy of your microphone and amplification system. This brings us to a most important point, namely "How is it possible to judge when sufficient power is being delivered to the cutter without actually making a test?" The usual method which is reasonably satisfactory rough as it seems is to feel the cutter while

rehearsal is taking place with, of course, the microphone and amplifier switched on. A distinct tremble should be observed. Another method is to tilt back the pick-up and insert an ordinary needle or piece of wire of similar diameter and clamp to it the diaphragm of a cone loud speaker, as in Fig. 31. The quality of reproduction obtained by this means will naturally be poor, but the volume will enable one to correlate that of the actual music and the recorded results obtained later.

Of course, a better method is that of monitoring the sound by a loud speaker working at the same time as recording is taking place. This, however, cannot be accomplished

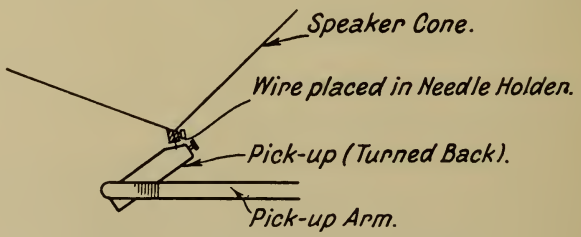


Fig. 31. Testing Recording Level

unless the recording is in a room separate from the microphone and performers. If a loud speaker and microphone are working together in the same room microphone "howl" occurs. In other words, the microphone passes sound via the amplifier to the loud speaker, which goes to the microphone and back again in a sort of reactive circuit. It is possible that a long room might be employed, but this is not desirable.

If loud speaker is to be connected to the output in parallel with the recording head or pick-up a test should be made on the quality of the recording because the addition of the loud speaker alters the conditions of impedance matching. In this connection reference to Chapter IX, page 176, will be useful.

Another important point in recording is to make absolutely certain that the room used as a studio is free from articles such as ornaments, etc., which sympathetically

(Cairns & Morrison, Ltd.)

FIG. 32. RECORDING BY THE CAIRMOR SYSTEM

vibrate at certain notes. The best way to check this is to run over the piano scale operating the keys heavily. It is not within the scope of this work to deal with the subject of acoustics, but it can be stated that rooms possessing heavy curtains, draperies, etc., are dead to sound, while others more or less free from impediments are reverberant. In recording this difference is appreciated in that rooms having a high sound absorption produce sharp, clear cut vocal effects, but lack brilliance. On the other hand, reverberant rooms are inclined to produce sound of a "ringing" type.

One way out of the loud speaker difficulty is to employ headphones for monitoring purposes after the style shown in Fig. 32, which illustrates the process of recording by the Cairmor system previously described. The distance of the artist from the microphone should be noted, as it is typical for this class of work.

The most difficult thing to learn in connection with home recording is how to achieve balance between vocal performers and various musical instruments. Usually best results are obtained when vocal performance is at a sound level above that of the accompaniment which is in the nature of a background.

Another one of the difficulties particularly associated with carbon microphones is "blasting." It is no use shouting at a microphone to obtain greater volume, since this merely overloads and creates recording similar to, but very much worse than, overloaded amplifiers.

One of the best tests so soon as you have your equipment in working order is to switch on microphone and amplifier and standing directly in front of the microphone with the amplifier volume control set to maximum and the microphone control set to the same level, to pronounce numerically the distance you are from the front of the instrument. Thus at 1 ft. you pronounce "One foot," at 2 ft. "Two feet," and so on gradually walking backwards. The same type of procedure can be followed for instruments, and these when played back will help you place various performers.

It is absolutely useless to endeavour to make a record

without one or two rehearsals, especially if the recording equipment is located in the same room.

As a matter of fact in the recording of commercial records three waxes are commonly cut, though strangely enough it is usually the first one which is eventually placed upon the market. Experience shows that you will almost certainly get the best recording from a musical standpoint when your subjects are not actually aware that recording is in progress. So soon as they realize that their efforts are being committed to a recording disc they become "stiff." This is an argument in favour of arranging amplifier and recording turntable in separate rooms.

If the recorder is employed for selections from radio programmes the ordinary procedure is followed except, of course, that the monitoring loud speaker can in this case be in the same room, since no microphone is present. Radio music may be used as a background for microphone performance providing the set be wired up properly.

Aluminium or similar metallic records require a cutting lubricant. Some recording discs are previously waxed, but most are supplied dry, and a small tin of grease included in the equipment.

Vaseline will usually be found adequate for lubricating aluminium, although somewhat heavier and cleaner recording can be obtained by the use of a trace of paraffin, which in engineering is well known to be the best cutting lubricant for aluminium. Whatever oil or grease is employed it should be carefully removed before playback is attempted, as otherwise the point of the fibre or thorn needle will rapidly be spoiled and the needle itself will slip the grooves. A rag moistened with methylated spirit will serve for removing any traces of grease, etc.

Recording Faults. If the amplifier is giving too great a volume the amplitude or "swing" of the cutter may be too much, and the grooves will come so close together as to throw the needle during replaying. The obvious cure for this is to reduce the volume, or the tracking device may be modified (in some of the systems at all events) so as to widen the pitch of the spirals.

An alternative method is to weight the pick-up although

this can only be applied within certain limits as it may very easily slow down the turntable.

If during replaying the fibre or thorn needle refuses to remain in track then it is probable that the recording cutter, especially if of the steel needle type, has become dull and requires replacement. Alternatively the weight on the pick-up should be increased.

If a high pitched whistle is heard or interference is noticed it is well to look to the connections of the various parts of the apparatus. Move them about with a loud speaker in circuit, and if necessary replace by means of lead-covered wires with the sheath earthed.

If the records vary in pitch producing what our American cousins know as "wows," this is due to variation on the speed of the turntable, which may easily be checked by means of the stroboscope as described in Chapter VIII, page 161. Before recording, the gramophone motor if of the spring type should be wound fully, and if the weather is especially cold running the motor down once or twice will serve to loosen grease with which the spring is packed.

With many of the recording equipments at present on the market sufficient care has not been given to the rigidity of the head and tracking device. A frequent source of trouble is looseness of recording head which can frequently be cured by attaching a rubber band or small spring to keep the head up against one side of the screw. Some systems are naturally more adaptable to such modifications.

If you find that vocal performance is satisfactory, but that music is an unnatural parody of the real thing then depend upon it that your microphone is at fault, and probably you will want a higher quality instrument. Incidentally carbon microphones should be tapped or shaken gently between records, as the carbon particles have a tendency to pack.

In commercial home recorders little attention appears to be paid to the insulation of the apparatus from incidental vibration due to movement about the room, street rumble, etc. In professional recording work no effort has been spared to insulate every section of the mechanism, and this principle may with profit be adopted by the amateur. Thus the recording turntable, etc., can be placed upon rubber feet or

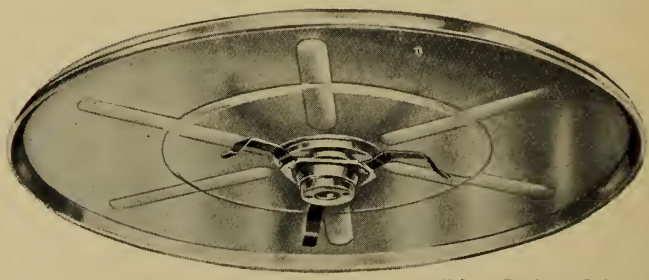
preferably upon a sponge rubber mat, and rubber washers may be fitted under the various sections of the apparatus. Remember that for good results every particle of vibration must be damped out of the apparatus except that due directly to the microphone impulses. Some motors run irregularly due to a variety of causes, amongst them being badly balanced governors. These should be corrected if best results are to be obtained. Sometimes in a home recorded effort one can hear distinctly the throb of the motor.

The turntable should always be set perfectly horizontal, and is best checked by means of a spirit level, remembering that two tests must be made, one at right angles to the other.

In playing back aluminium records it will usually be found that the weight required on the pick-up is less than with the ordinary type of gramophone records. A modification can be made to the pick-up by use of some type of counter weight. In this connection refer to Fig. 17*b* showing the adjustable weight of the Kingston-Wearite system.

One of the great difficulties of home recording is the elimination of scratch or ground noise as it is sometimes called. This is due to a variety of reasons, among which are insufficient lubricant, a cutter with a point which tears rather than scribes or cuts, and aluminium too soft or too hard. Incidentally, although most home recording discs are advertised as "special aluminium alloy," in the findings of the writer they are usually aluminium having a purity over 99 per cent and of hard temper. Better results can be sometimes obtained with medium temper, and one frequently finds that in a batch of, say, a dozen home recording discs one or two are markedly better than the others. Incidentally the amateur may find it cheaper to purchase aluminium in the sheet form and cut it into discs by means of shears. A suitable thickness is 0·18 in., which corresponds to 26 S.W.G. For small records say of 6 in. diameter a thinner material may be used for economy, a common thickness being ·010 in., which corresponds to 32 S.W.G. This also is employed on the small 3 in. diameter record cards which can be sent by post, and will convey a short message or seasonal greetings.

Recording at 33⅓ r.p.m. In the foregoing we have assumed that the recording speed adopted would be 78 r.p.m. Of comparatively recent date interest has been aroused by records running at a speed of 33⅓ r.p.m., which are known generally as "long playing records." This speed has achieved considerable popularity in America, and it is likely that in the near future it will be adopted in Great Britain, for certain classes of subjects at all events. The one advantage of the 33⅓ r.p.m. record is, of course, that it lasts longer.



Slektun Products, Ltd.

FIG. 33. 78 R.P.M. TO 33⅓ R.P.M. REDUCTION TURNTABLE

From the point of view of home recording this may be of no great importance, but the reverse is true in connection with the making of talking pictures, as described in Chapter IX.

Straight away it may be said that the quality of recording at 33⅓ r.p.m. cannot be better than at 78 r.p.m., and is, indeed, usually considerably worse due to the reduction in speed.

Nevertheless quite good results may be obtained either on the special pre-grooved type of record designed for 33⅓ recording or from plain aluminium discs. The one thing to remember is that all the difficulties of the faster speed recording are multiplied when we are working at 33⅓ r.p.m. The motor must be carefully governed. This raises the difficulty that no ordinary gramophones are capable of turning at this speed, although some of the recording machines marketed have a change of speed device enabling

them to rotate at either 78 (more probably 80) or 33⅓ r.p.m. as required. To meet this difficulty the writer devised a type of turntable which replaces the existing one on any type of gramophone and automatically reduces the speed of rotation from 78 to 33⅓ r.p.m. This device is simple in the extreme, and is illustrated in Fig. 33. It is quite satisfactory from the point of view of reproducing, and works well for recording, providing care be taken that the fitment to the gramophone spindle is rigid. Adaptors can, of course, be used to suit any types of machine spindle. Fitment is simple since one merely removes the existing turntable and replaces it by the new one, there being no screws, etc., or holes to be drilled anywhere. It may seem a simple matter to reduce the speed of a gramophone, but actually there are only one or two methods which give results of either playing back or recording, free from "wows."

In the R.C.A. 33⅓ pre-grooved home recording records the grooves themselves are brought closer together, and this renders the process of home recording more critical. The chief point to remember in using these records is that the pressure of the recording point must be as light as possible consistent with maintaining track. The recording heads or pick-ups used for this purpose are frequently fitted with a special fine adjustment screw, which enables the weight to be changed by small fractions of an ounce.

Although for ordinary sound recording apart from talking picture work, the use of 33⅓ r.p.m. records may not be adopted, it is always well to bear in mind that if we have a subject which extends somewhat over the time given by, say, a 10-in. aluminium disc this time can be extended simply by slowing down the turntable by resetting the governor. This will make no appreciable difference to the quality providing, of course, that in playing back, the governors are adjusted to give the correct pitch.

For general work, however, it is suggested that the amateur will do well to maintain a definite turntable speed, as this will enable him to gauge programme length fairly accurately.

CHAPTER V

TALKING PICTURES

Development and Principles. The talking picture to-day is the greatest entertainer known, and has reached this state in the course of a few short years as the outcome of concentrated technical effort. Nevertheless it is not, as some might suppose, a recent invention having its inception as far back as 1866, when the matter was discussed by Edison and Muybridge. In 1893 Edison produced his *Kinetoscope*, which was exhibited at the World's Fair in Chicago. This was a peep show moving picture, and for a time was very popular. Soon after the same inventor combined his *phonograph* with the *Kinetoscope*, re-naming it the *Kinetograph* which may well be considered the first talking picture.

The years which followed saw the growth of cinematography into a large industry, but in the rush to produce films and build cinema theatres the talking side of the question was almost entirely forgotten. Nevertheless a small band of inventors plodded onwards, and a number of different pieces of apparatus was produced, some of which gave surprisingly good results. In fact, it is true to say that practically all the principles employed in present day talking pictures were set down in the early part of the present century.

Why did the talking picture remain dormant for so long? The fact of the matter was, as stated above, that the industry moved too quickly, and as cinema theatres became bigger and bigger the horn of a single gramophone could not furnish sufficient sound to fill them. To-day we can obtain as much volume as required by electrical amplification, but this was not possible until Dr. Lee De Forest in 1908 added the grid to the valve invented a few years earlier by Sir Ambrose Fleming.

The first result of this invention was the development of radio, and then the electrical recording of gramophone

records as mentioned in the first part of this book. Electrical amplification being possible the talking picture became a commercial proposition. It took some years, however, to develop the system to a practical stage which appeared to be reached about 1925. The names associated with the commercial development of talking pictures are Dr. Lee De Forest, Theodore W. Case, and the research staff of the Bell Telephone Laboratories, which developed the system now marketed by the Western Electric Company who, in the early days, were working in conjunction with Warner Brothers Vitaphone of *Singing Fool* fame.

The *Jazz Singer* and the *Singing Fool* were the first big pictures to be screened in America. Theatres were deserted, and everyone rushed to see the new entertainment. Some thought it was too novel to last, but more and more pictures were produced, and still the cinemas remained at full capacity.

The same thing happened here in England when in September, 1928, the Piccadily Theatre first exhibited the *Jazz Singer*. Then came the *Singing Fool* at the Regal Marble Arch which was even better. Gradually more and more talking pictures infiltered, the public acclaimed the talkie, and an industry was remade.

This is a very brief sketch of the history of the talking picture, and many great names have been omitted.

Amateur Cinematography. Nowadays amateur cinematography is becoming commonplace, and bids fair to be one of the most popular hobbies. Although it has received impetus in the past few years only, it is by no means a recent development, and many amateurs were busy as far back as 1900.

Undoubtedly the present state of cinematography is due almost entirely to the introduction of sub-standard films, by which we refer to 16 mm., 9·5 mm., and the new 8 mm. films. Even these, however, were foreshadowed in 1900.

It is always so with any new development. So soon as a new process or invention becomes commercially practical companies are formed for the exploitation of the apparatus as grist for a new hobby. Usually a number of enthusiasts take it up and it potters along for a few years and finally

relapses only to be again brought to the fore when prices have dropped due to the development of mass production.

This is particularly true of amateur cinematography. In the early days it was a hobby only for rich. To-day practically everyone can enjoy the thrill of taking and showing their own films. More than this the technique has been reduced to the setting of one or two stops and the pressure of the button. Amateur cinematography of to-day can well claim in the words of a large company to "have the bother left out." Some of us, perhaps, are not too pleased with this but, until an art or industry has reached the stage where anyone without particular training or experience can work the apparatus it never becomes popular and thus never cheap.

The state of development of amateur cinematography in this country is by no means as great as in America, where it has almost completely ousted the "still" camera and album. In America people to-day do not thumb over albums or photographs of their last holidays, but instead open the screen and run through a hundred feet or so of film to show their admiring friends exactly what did happen. In this country we are in the habit of saying we are more conservative, and thus things develop more slowly. Actually, of course, the real reason for our tardiness lies in the fact that our home market is so much smaller than in America, and thus prices are higher. In America to-day, for instance, it is possible to obtain a complete cinema camera for a price equivalent to £2. In the next few years prices of all amateur cinematograph requisites are likely to fall considerably.

It is not probable, however, that the silent cinema for domestic purposes will ever develop in this country to the state it is at the present moment in America. The reason for this is that the amateur talking film has now reached the state when it can be introduced into homes. Thus if home talking pictures are available who will bother with the silent? Of course, the question of taking one's own films certainly complicates matters, and so we might suggest that in the near future while home talking pictures will become popular, amateurs will still for some considerable time continue to take silent films.

We are told that very shortly television will become world wide and commercial. This may be so but, in the opinion of the present writer, television will come after the boom of the home talkie. We are now in a very peculiar state with regard to mechanical entertainment. We have radio—this is commonplace. We have gramophone records, but, some of us are tiring of them. To what must we turn? Obviously the home talkie which will give us sound and

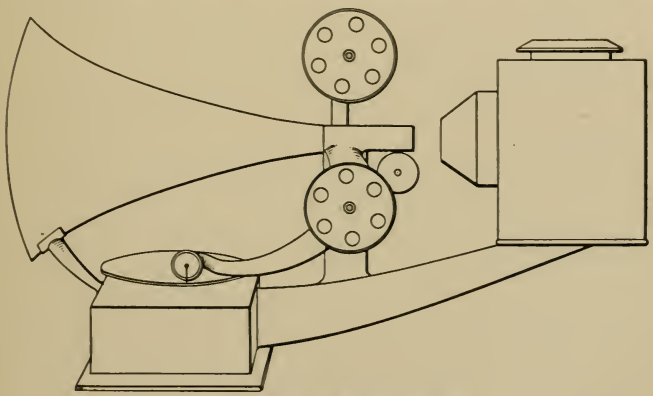


FIG. 34. THE PHOTOPHONE

picture, or, in other words, something very close to the ultimate illusion of the stage.

Early Home Talkies. All great inventions start in somebody's workshop at home, and thus the early talkies were most certainly of the domestic variety. Look, for instance, at Fig. 34, which shows the *Photophone*, an ingenious combination of gramophone and cinematograph in which the difficulty of the large horn is overcome by projecting the beam of light through the throat. The whole apparatus is quite neat even according to modern standards, and possesses only one disadvantage which renders it of doubtful value. Sound and picture emanate from the same point, which means to say that if we are projecting on a screen we shall see the picture at one end of the room and hear the voice from the other. This is entirely wrong, since illusion

is destroyed. If the picture is to talk then the sound must issue close to the picture, and in approximately the same direction as the voices of the screen people were they actually present.

Silent Projection. Before we proceed to consider the question of the talking picture we must first run over some of the main points of ordinary silent projection. In the first place the moving picture is made possible by a defect or limitation of the human eye. If we are looking fixedly at a particular object which is instantaneously snatched away we still retain an impression of that object for a fraction of a second afterwards. This phenomenon is known as "persistence of vision," and upon it is based the whole of cinematography.

A cinema camera is simply an apparatus for taking a large number of photographs one after the other, while the cinema projector throws these on to a screen in a precisely similar manner. What actually happens when we are looking at a cinema screen is that we are shown one picture for a fraction of a second, then a shutter comes down and completely shuts off the light during which period the picture is replaced by the next in the series. Then the shutter is lifted and we observe a picture differing slightly from the original one and progressive. Our eye cannot respond as quickly as the change of picture, and thus blends the whole series into one which moves. If our eye had no persistence of vision a cinema film would merely be a series of monotonous lantern slides.

Stated as above the problem of making a cinema camera and projector seems simple, but considerable mechanical difficulties had to be solved before these instruments became practicable. In principle projector and camera are very similar. In Fig. 35 we see an outline drawing of a silent cinema projector. This actually follows the lines adopted in the professional machines. We find that it can be grouped roughly into two parts—optical and mechanical. The optical system consists of an illuminant, in this particular instance an arc lamp, and an objective. The light may first be concentrated by a condensor before being thrown on to the film transparency. After it has passed through the film

it has to be collected and projected on to the screen. This collection takes place by means of an objective lens.

The mechanical side is somewhat more complicated but is simple in principle. Since the film is of considerable length it has to be carried on a reel of some sort known as a spool,

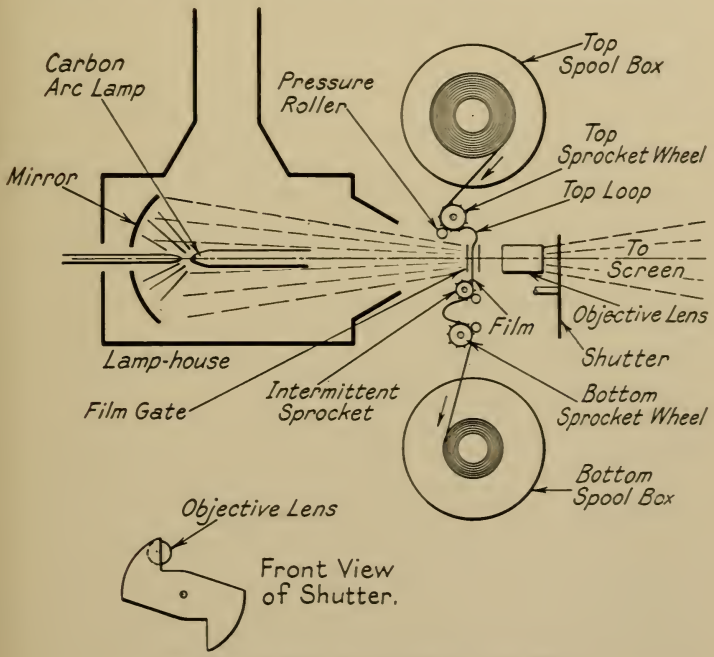


FIG. 35. PRINCIPLE OF SILENT PROJECTOR

from which it runs over a toothed sprocket, through the gate of the mechanism which is simply a device for holding the film flat past an intermittent mechanism, over another sprocket, and so down to a re-wind spool.

The vital part of cinematography is the intermittent mechanism mentioned above. There are a good many types of these, but they all perform the same function. The film does not, of course, run from one spool through the gate to

another, in as it were a continuous flow. What happens is that we have an intermittent mechanism usually in the form of a claw which snatches the pictures down one by one. The remainder of the mechanism such as the spools and sprocket wheels are merely to prevent strain on the claws, and to provide facilities for rewinding.

Linked closely with the intermittent mechanism is the shutter. This is a device of many forms which completely shuts the light from the screen during the period in which the pictures on the film are dragged down.

There are scores of types of cinematograph projectors on the market, but all with few exceptions follow the principles outlined above. In the following pages appear illustrations of several popular makes. An examination of these will show the various parts, which may be compared with those in the diagram in Fig. 36.

It is not within the scope of the present book to deal in detail with the camera side of amateur cinematography. Suffice it to say, therefore, that the cinematograph camera operates in a similar manner to the projector, except, of course, that we are employing sensitive film and not transparent pictures. An inverse action takes place in which the reflected light from our subject passes through the objective lens of the camera, and thus falls on to the sensitive surface of the film. No illuminant is employed, and the whole of the mechanism is constructed perfectly light tight. The mechanical side of cameras is similar to that of projectors, except that for convenience it is common to have cameras driven by small spring motors or cranked by hand, whereas nowadays nearly all projectors are driven by electric motors.

Synchronized Sound-on-Disc. In the previous part of this book we have dealt in some detail with the methods of recording sound by means of discs. We have, therefore, a sound record by the gramophone and a picture record by the cinematograph. If we can make these separately we should be able to make them at the same time and of the same subject. This being possible, if we start the gramophone and the cinematograph projector at precisely the same time we shall have a talking picture of some sort.

As is probably known this forms the basis of the principle of talking pictures by the "Sound-on-Disc" principle.

If we take a recorder and couple the turntable driving-mechanism to a camera so that the relative speeds are suitable we shall have the skeleton on a sound-on-disc talking picture recorder. In Fig. 36 we see the schematic diagram of sound-on-disc synchronized recording with a flexible shaft coupling. If we are recording at 78 or 80 revolutions

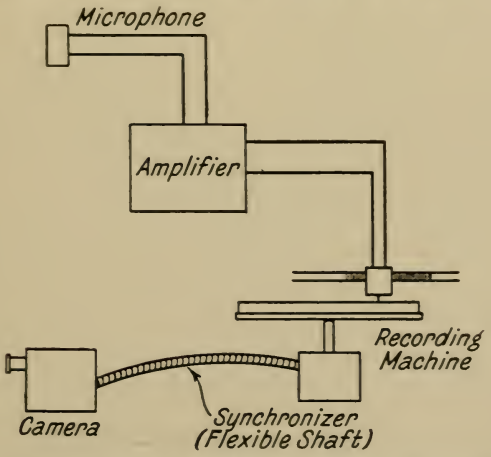


FIG. 36. PRINCIPLE OF SOUND-ON-DISC RECORDING

per minute the turntable must rotate at this speed, and thus we must have gearing to the flexible shaft at both ends between turntable and camera. The camera must, of course, run at a speed which will give us ordinary animated pictures. For silent purposes this is usually taken as 16 pictures per second, and there is no reason why we should depart from this for general purposes, although this subject will be discussed at greater length in a later chapter, since it is closely related to the economic side of the question.

In commercial disc recording this arrangement is not adopted nowadays, since it has been found essential to keep the recording machine at some distance from the camera. Flexible shafting is useful only when it operates

at a distance of, say, half a dozen feet. Sometimes cameras photographing a scene are 100 yd. away from the sound recording studios. Thus use has to be made of what is known as the "electrical interlock." For our present purpose we may regard this as a method of wiring or connecting the electric motor driving the turntable with that driving the cinema camera. For amateur purposes we rarely use electric motors for driving cameras, but this is always the rule for professional talking picture work.

In projecting sound-on-disc there is firstly a projector, and secondly a turntable operating a suitable pick-up or a sound box if we are relying upon acoustic reproduction. The turntable must be connected to the projector mechanism in precisely the same way as was the camera when the photographs were taken. This again may be by means of a shaft or electrically.

In projecting a sound-on-disc talking picture, therefore, we have to start the film and disc at such a point that sound and picture synchronize. By this we mean that if on the disc a person shouts, just at that precise instant so must his lips open on the cinematograph film. This is fairly easy providing we put what is known as a "start mark" on the record, and an indication of the corresponding picture on the film. In the earlier section of this book the question of the $33\frac{1}{3}$ revolutions per minute record has been discussed, and this is used exclusively by professional sound-on-disc recorders. The start mark appears as is shown in Fig. 37, *A*, where it will be seen that a radial line indicates the actual start and a sharp lead in spiral connects this with the remainder of the record groove. It will be remembered also that for talking picture work the sound record starts at the middle and works outwards. So that we shall know the exact point of the film which must be in the gate of the projector this is usually marked as is shown in Fig. 38, *B*, by the word "START" printed across one of the frames. This is placed in the gate of the projector, and the record and pick-up arm are manipulated so that the needle rests on start mark at the same time. For convenience a series of arrows are sometimes inscribed on the film as shown also at *C*, so that if when threading the film start mark is overshot we

shall know in what direction to turn the mechanism to regain it.

So much for starting the film and disc at the right period.

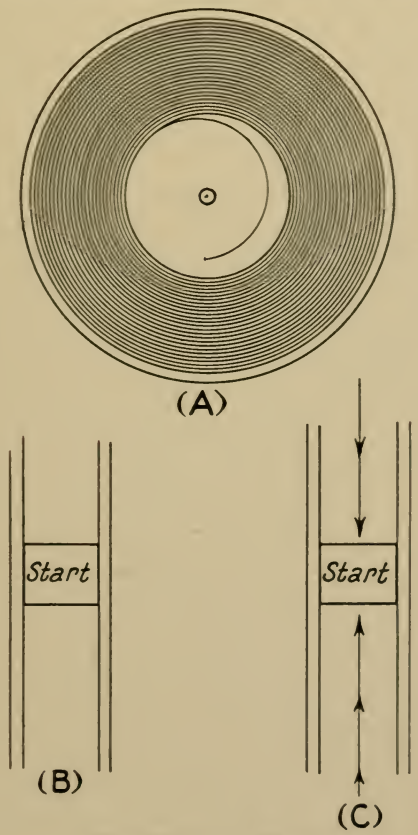


Fig. 37. Start Marks

This is not sufficient, they must keep in step or phase all the time, and be absolutely free from variation in speed. From the point of view of the silent projector it mattered very little whether the speed of showing was the same as

that of talking. In fact, pictures were usually projected somewhat faster in action than they were taken. In talking picture work, however, it is absolutely essential that films be shown at precisely the same speed as they were taken, as otherwise voices change in pitch. If turntable and projector are coupled direct by shafting there can be no question of cinematograph getting ahead or behind turntable except by

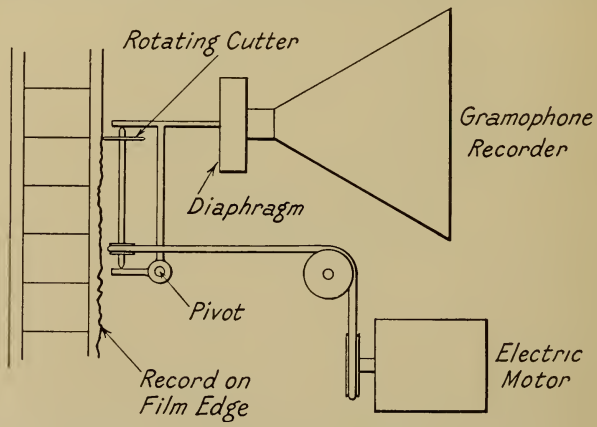


FIG. 38. FILM RECORDER OF MRS. VON MADELER

the jumping of the needle on the disc, which should not, of course, take place providing care be taken.

Sound reproduction will take place by some form of loud speaker unless we use an acoustic gramophone.

Synchronized Sound-on-Film. Disc recording in association with synchronized pictures is satisfactory, but suffers from one fault—the two recordings are carried on different media. On a strip of celluloid we have the picture, and on a disc we have the sound. If everything is all right picture and sound will be in step, but we are always faced with the difficulty of starting and keeping them in phase. Obviously a better method would be to employ one medium which should carry both pictures and sound.

There are apparently two alternatives, bearing in mind our existing knowledge of the subject. Either we must

place the picture on the disc or the sound on the film. In the early days of the cinema a series of pictures were arranged round a transparent disc which conceivably might have possessed grooves. Nevertheless a little consideration will show that this is practically out of the question, which leaves us with the method of putting the sound as well as the picture on the film.

The most obvious method of doing this is illustrated in Fig. 38, which shows the film recorder of Mrs. Von Madeler. This is, of course, quite an early effort, as will be appreciated when one notes the acoustic recorder and horn. Here we find that the vibrations of the recorder diaphragm set in motion a linkage carrying a rotating cutter which is pressed against the edge of the film. The cutter is driven by means of an electric motor which is arranged so that it has no appreciable effect on the movement of the cutter other than in rotation. As a diaphragm of the recorder vibrates according to the sound striking it the cutter is pressed more or less into the edge of the film, and thus cuts out a wavy record. The reproducing machine is obvious, and in it a sapphire pointed stylus was held against the film edge which vibrated as the latter moved.

While the idea of this device seems sound enough it is open to numerous mechanical objections. It is well known that a vast amount of time was spent in research conducted to produce suitable media for giving gramophone reproduction free from scratch and surface noise. A similar amount of work has been expended in the perfection of celluloid for bearing the pictures. It is inconceivable that both these qualities can be obtained in a single medium. Actually ordinary celluloid film was employed which while admirably suited from the point of view of carrying the photographs was totally unfitted for good quality gramophone reproduction. Furthermore, one shudders to think of what happened when a film joint passed the stylus bar.

Considering the question further it becomes evident we must record sound in a similar manner to picture, i.e. a sound record must be made by photography. In this latter we have light and shade with which to work, and by

variations have to obtain the fundamentals of sound—volume and frequency.

The first idea is that we should reproduce the wavy groove of the gramophone record on the film, and devise an optical arrangement for picking it up and converting into suitable impulses. We shall thus have to rob some of the picture space. In commercial sound-on-film using standard size

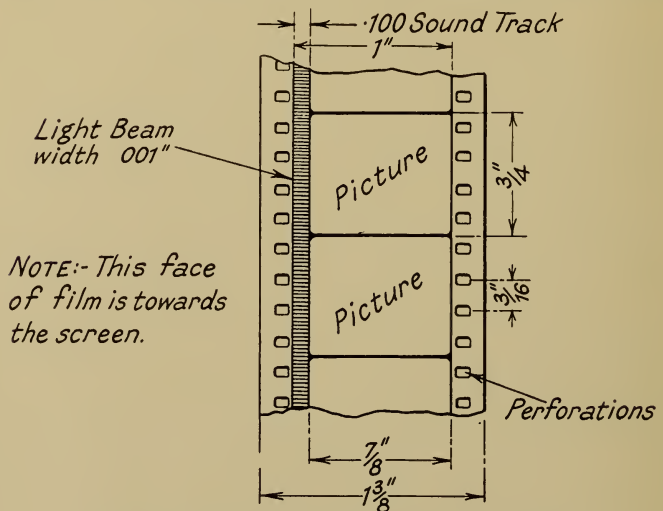


FIG. 39. SOUND FILM SIZE—VARIABLE DENSITY

stock this space is approximately one-tenth of an inch wide, as shown in Fig. 39, and is known as the sound track. Thus the picture is somewhat more square in shape than usual. On this space we have to obtain a sound track which must give variations in pitch.

For the sake of argument let us suppose that we have a film bearing down its sound track space a wavy sound curve as shown in Fig. 40 *A*, which has by some means been obtained through the medium of microphone and amplifier. We have now to covert this into actual sound. It is fairly safe to assume that we shall think first of converting into

electrical impulses and these to sound by means of amplifiers and loud speakers.

Since we are dealing only with light and shade we shall have to use an illuminant and possess some device which when actuated by variations of light will set up electrical impulses. Such a device is the photo-electric cell. For our present purpose we may consider a photo-electric cell as a device which changes its electrical characteristics according to the amount of light falling upon it. Fig. 41 shows diagrammatically one of the most used photo-electric cells which in appearance is somewhat similar to an electric lamp or bulb. Up the middle of it runs a metal loop which forms the anode, and round the inside of the bulb is a layer of potassium hydride which varies its electrical characteristics according to the amount of incident light. This is connected to a flexible lead by being coated upon a silver layer as shown in the diagram. At the front of the cell we find a window through which a light beam may pass. This strikes the potassium hydride cathode and causes it to emit a stream of electrons which enables current to pass between anode and cathode after the style of the radio valve. This is a crude explanation of the working of this type of photo-electric cell. Many other materials exhibit similar properties to potassium, and the earliest experiments employed the metal selenium which varies its electrical conductance according to the amount of light falling upon it. The action of the photo-electric cell is somewhat different to the selenium cell but produces similar results.

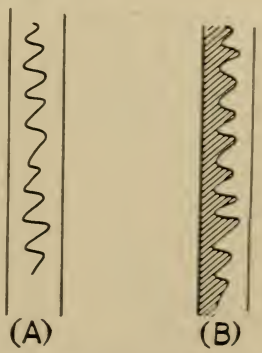


Fig. 40. Sound Track Principle

Fig. 42 illustrates diagrammatically the showing of a sound-on-film talking picture. Here we find the film passing two illuminants, one for picture projection the other known as the exciting lamp, for throwing a small beam of light on the sound track. This light after being intercepted by

the film falls upon the photo-electric cell which is connected to a valve amplifier and thence to a loud speaker.

Now if we refer again to Fig. 40, *A*, giving our sound graph we shall find that the amount of shadow or darkness on the sound track is constant. This obviously is wrong, since it will give no variation to the total amount of light falling on the photo-electric cell. Suppose, however, we fill

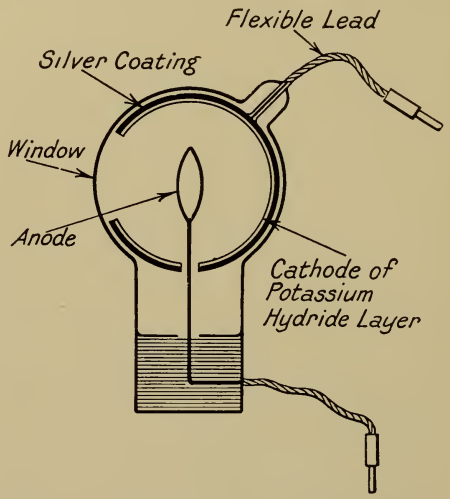


Fig. 41. Diagram of Western Electric Photo-electric Cell

in one side of the graph as shown in Fig. 40, *B*. The distance apart of the peak on the graph produces frequency as in the ordinary gramophone record, while the ratio of dark to light will give us variation in loudness. Thus we obtain our sound track, an example of which on a standard size film is shown in Fig. 43.

There is another type of sound track which is somewhat different in appearance, although it gives similar results. This is illustrated in Fig. 44. The two types of sound track are known respectively as "variable width" and "variable density." The latter method is not quite so obvious in its

method of recording sound. Differences in loudness is recorded by difference in density of the sound track, while pitch is recorded as the number of dark to light variations per unit length of the film.

Recording Sound on Film. Fig. 45 shows diagrammatically a method of recording a film. Here we find the microphone and valve amplifier coupled to a sensitive lamp bulb

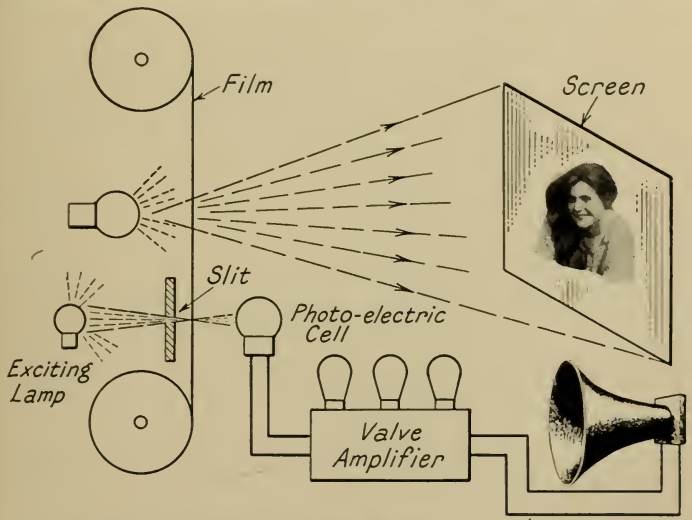


FIG. 42. SHOWING A SOUND FILM

which throws a narrow beam of light on the side of the film. According to the impulses given to the amplifier so does the intensity of light from the bulb vary, thus a sound track, of variable density, is produced on the edge of the film.

For recording variable width sound track an arrangement shown in Fig. 46 is commonly employed. Here a lamp throws a beam of light on a small mirror contained in an oscillograph. This latter may be considered as being a very sensitive voltmeter or ammeter, which is coupled up to the microphone *via* the usual amplifier. From the oscillograph the reflected beam of light is thrown upon a

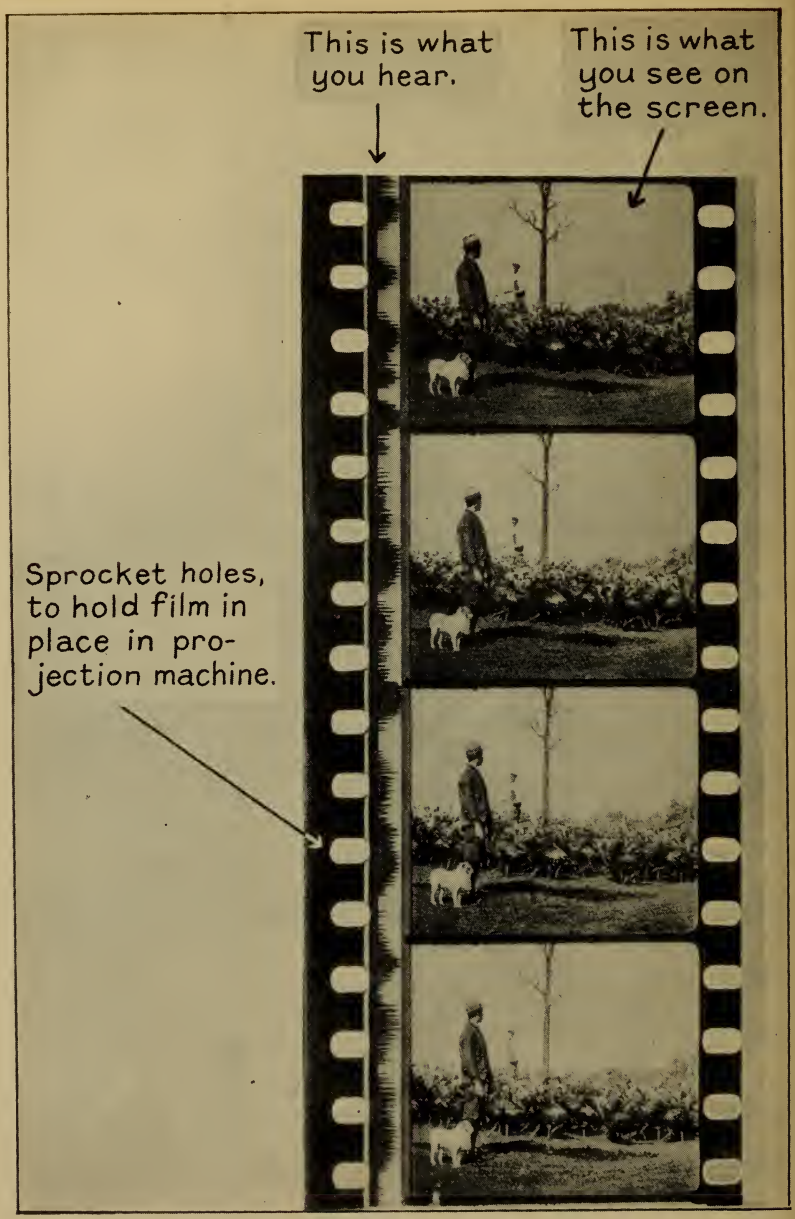


FIG. 43. SOUND FILM
(Variable Width)

(Western Electric Co., Ltd.)

FIG. 44. SOUND FILM
(Variable Density)

shield having a slit which covers the negative film. As the impulses are given to the microphone and magnified by the amplifier, the mirror moves and causes the beam of light to move backwards and forwards along the slit, tracing out a wavy track of sound after the styles of Fig. 43.

Film and Disc Compared. Having now considered briefly the methods of recording and reproducing both by the usual

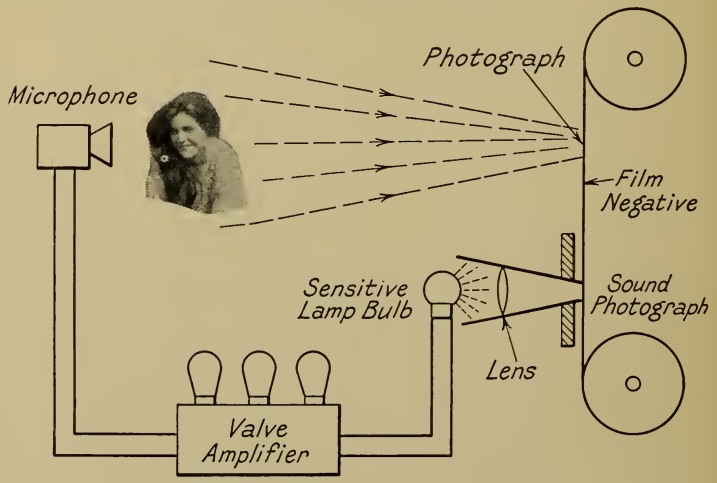


Fig. 45. Recording a Sound Film

sound-on-disc and by sound-on-film, we may well inquire which is the better. This requires explanation.

In the early days of talking pictures it was generally acknowledged that sound-on-disc reproduction was better in quality than sound-on-film. This was due to the fact that sound-on-film recording was an entirely new art. At the present day we should be correct in saying that the conditions are reversed. A further point in this connection is that recording by means of sound-on-disc, at a speed of $33\frac{1}{3}$ revolutions per minute and not the old 78 of the gramophone record, cuts down the speed of running, and tends to reduce quality. Thus it is that we are now comparing highly developed sound-on-film against sound-on-disc, which did

not pretend to be even as good as that of the ordinary gramophone record.

For many years during the life of the silent cinema it had been common to project pictures at the rate of 16 per second, this being considered sufficient to give true illusion of all types of natural movement. The coming of the sound-on-film talking picture caused a change, and it was discov-

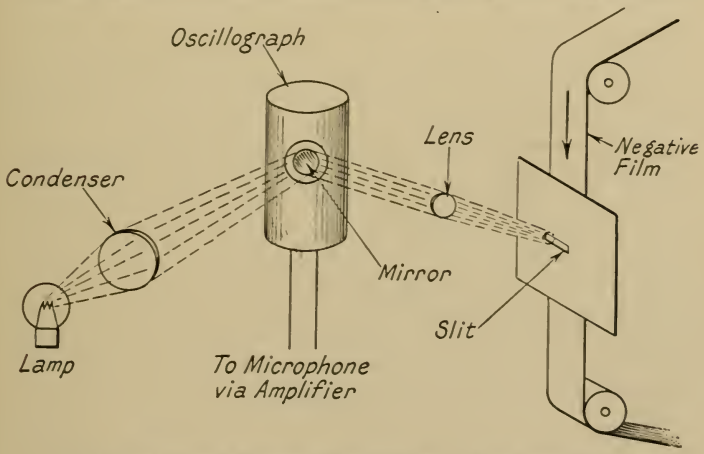


FIG. 46. VARIABLE WIDTH RECORDING—THE OSCILLOGRAPH

ered that to provide adequate reproduction of the high notes a speed of 24 pictures per second was required. In other words, the film speed was increased from 1 ft. to 18 in. of film per second.

Clearly, the quality of reproduction reproduced from a sound track is entirely independent of the number of pictures included in the film, and is measured only in the actual length of film passing the exciting lamp beam and the photo-electric cell. Thus when we turn to the home talking picture we are immediately in trouble. The old silent cinematograph either in 16 mm. or 9·5 mm. film ran at a speed of about 16 pictures per second (14 pictures per second is standard for 9·5 mm. film). We cannot, however, merely increase the number of pictures per second up to 24, add a sound track,

and expect to get results comparable with those of the standard size film. The reason for this is the smallness of the picture size where 16 pictures of 16 mm. merely amount to 5 in. and 24 to 7½ in.—the latter as against the 18 in. of standard 35 mm. stock. The indication is that if we are to expect reproduction as good as the standard film we shall have to speed up the film considerably—at least three times its present speed. This means that the cost of film would rise proportionally—not a very pleasant prospect!

Another point arises, and that is that the smallness of the picture in 16 mm. or 9·5 mm. film is such that the introduction of a full width sound track would be out of the question. Thus the size of the sound track would have to be reduced so that it occupied a corresponding ratio to that of the 35 mm. film. The question is really about the same as with the gramophone record, where for good quality we want a reasonably high speed of running and, in gramophone terms, fairly widely spaced grooves.

Perhaps from the preceding paragraph it may be imagined that 16 mm. or 9·5 mm. sound-on-film is out of the question. This is by no means the case, as several systems are described in a subsequent chapter.

In the future, sound-on-film for home talkies will reign supreme. Of this there is little doubt, but at the present state of affairs we are safe in saying that sound-on-disc must have its run. It possesses a further advantage in that no great stage of amplification is necessary. That is to say that one's ordinary radio set or radiogram may be pressed into service without the addition of a photo-electric cell amplifier. The electrical output from a photo-electric cell is lower than that of the electrical pick-up, and extra amplification is required.

In professional talking picture work 24 pictures per second has been adopted both for sound-on-film and sound-on-disc recording. This is not really necessary, for clearly the rate of projection used for silent picture work would be adequate for use with sound-on-disc. The real reason why 24 pictures per second speed was adopted was so that no change in projector gearing was necessary, and that all talking pictures, whether on film or on disc, should be

projected at the same speed. But with the home talkie things are rather different, and it is not likely that a combination of sound-on-film and sound-on-disc would be required.

Unfortunately, many of the home talkie films at present available have been printed down from the original full sized film and thus run at 24 pictures per second. This is not necessary, as will be explained in a later chapter, neither is it desirable from the point of view of the projector. Silent projectors were made to run their best at 16 pictures per second, and although they will run faster they are apt to become noisy.

Another point in favour of the sound-on-disc method for home talkies is that it is possible for certain types of apparatus to utilize the ordinary sound box or acoustic type of gramophone for reproduction. This means that the purchase of an electrical amplifier is not essential, and that people possessing some of the old style gramophones may yet enjoy talking pictures in their homes. Radio enthusiasts may possibly wrinkle their noses at this statement but, in spite of the development of electrical amplification, good acoustic gramophones can still be considered comparable to a large number of the more modern electric type.

Again, projectors vary so much in construction that a sound-on-film reproducing apparatus that is universal is almost out of the question, which means that existing silent machines would have to be completely replaced.

Summing up, we may say that while eventually the sound-on-film method of recording will be adopted generally for home talking pictures, at the present time, and probably for some years to come, the disc method will be popular. The use of sub-standard sound film with the sound track will probably be confined to advertising and educational purposes for some considerable time, because in both of these cases the initial cost of the apparatus is of less importance than that of the home talking picture proper.

16 mm. and 9·5 mm. Compared. For a long time there has been controversy about the respective merits and economies of the 16 mm. and the 9·5 mm. film. From the point of view of the home talkie utilizing a disc it is

immaterial which size film is employed. With regard to the sound-on-film, obviously the 16 mm. offers the advantages of a larger space on which to print the sound track. It must not be thought, however, that the sound tracks cannot be printed on 9·5 mm. film. In fact, it can be accomplished with relative ease by a method given in Chapter X and invented by Mr. Will Day.

Amplifiers and Loud Speakers. Before describing equipments in more detail a few remarks on amplifiers and speakers may not be out of place. The first thing about the home talkie as far as the sound is concerned is that it must be as natural as we can make it. It is, therefore, obviously out of the question to couple up a ten-year-old radio set to a modern home talkie projector, and expect good results. Considering for the moment sound-on-disc talkies there are several stages at which bad quality reproduction may be introduced. First, there is the record or disc which is beyond our control unless we happen to be making it ourselves. Secondly, there is the electrical pick-up, and if this is inferior good results are impossible.

The next step is the amplifier, and here we are likely to encounter another snag. The ordinary portable radio set amplifiers are insufficient and indeed practically useless from the point of view of home talking picture work. Wherever possible a mains-operated amplifier should be employed. This does not mean that satisfactory results cannot be obtained by a battery-operated amplifier, but that there are not many suitable ones on the market.

The point of the matter is that for natural results we must have a certain volume of sound, and this volume of sound demands a certain electrical output from the amplifier, which cannot readily be obtained through the medium of batteries. Of course, amateurs with no mains supply must make use of stored electricity, but they will have to endure battery replacement and charging somewhat higher than for radio work.

The type of amplifier required should have an output of at least three-quarters of a watt and preferably about two watts. Incidentally it may be remarked that the latter is given by most of the modern indirectly heated pentode

valves which are now used on many modern radio sets operating from mains.

It we are purchasing an amplifier especially for use with our talking picture projector we shall not require more than two valves for sound-on-disc. The case of sound-on-film is different, but we do not expect that many amateurs will consider making up their own circuit, as the question of screening and impedance matching is somewhat critical.

We hear a great deal about straight line characteristics of amplifiers, and naturally the more uniformly an amplifier magnifies the electrical impulses supplied to the grid of its first valve, the better it will be as an amplifier as a whole. We do not think the amateur need worry himself very much about this providing he purchases a really good piece of apparatus from a reputable firm, such as illustrated in Fig. 29.

If you happen to possess a radiogram there is no need to purchase an extra amplifier. All that it is necessary to do in that case is to remove the pick-up leads and arrange them so that the leads from the talking picture turntable may be plugged therein. Quite conveniently we may be able to make use of the existing loud speaker which brings us to another subject.

Much has been written on the subject of loud speakers, and literally thousands of patents have been filed each claiming special advantages. In spite of this it is safe to say that at the present moment the moving coil loud speaker gives the best quality reproduction. In the opinion of the writer, really good and natural results cannot be obtained unless a moving coil preferably or an inductor loud speaker be employed. On the market now there are a good many excellent examples of the balanced armature or reed type loud speaker still existing. They may serve well for radio purposes but not for home talking pictures. Theoretically there may be little difference, but practically the talking picture demands a higher grade of reproduction than radio.

There still seems to be some confusion as to whether permanent magnet or separately excited moving coil loud speakers are the better. There is actually no difference, and both methods achieve the same object, viz. providing

a suitable magnetic field for the moving coil. The advantage of the permanent magnet loud speaker is that it requires no field current, and thus may be used with a battery-operated set. The loud speaker having a large field coil obviously cannot be used with a battery set unless electrical mains also are available, and even in this case one would still require some device for rectifying the current if A.C.

Illusion and Screen. As mentioned earlier in the present chapter a talking picture is not made simply by synchronism between sound and picture. It is not sufficient by any means for the lips on the screen to move at precisely the same time that sound is emitted from the loud speaker. It is imperative that the sound given forth is of a volume or loudness suited to the size of the picture, and also that the sound is projected from a position approximating that of the picture.

Putting this into more practical language is to say that we must not have a large picture and a whispering little voice or *vice versa*, and also that the loud speaker must be near the screen and with its "business" end pointing from the screen towards the audience. If any one of these rules be broken you are likely to lose illusion, and at the same time your true talking picture. The ideal arrangement is where the loud speaker is placed behind the screen. This position is adopted almost universally for professional purposes, and to a large extent in the case of the home talkie.

This raises a point sometimes brought forward that if we place the loud speaker behind the screen much of the sound will be cut off. Theoretically this is correct, but practically the difficulty creates no particular trouble. In cinemas, screens are specially made so that they are "sound porous." The early ones were woven in a particular manner so as to let the sound pass through. The later type of screens possess a large number of small holes through which the sound passes. Actually, however, from the point of view of the home talkie we may say that if the loud speaker is placed behind the screen the loss in volume is small. Of course, if your screen happens to be of plywood painted white and rubbed down you *may* have to make a different arrangement.

The point we wish to emphasize here is that if you possess a radiogram and wish to utilize its amplifier and loud speaker then you will have to put your screen before the cabinet and project thereon. It is no use fitting your projector at one end of the room, wiring up through your turntable to your radiogram, say, half-way along and projecting to the screen at the other end of the room.

We have heard a number of home talkie sets in which the loud speaker was set at the side of the screen. In a dark room this may serve well enough, but the sight of a loud speaker tends to destroy illusion, and if not behind the screen it is better suitably masked. It should always be remembered that this art is illusion pure and simple, and whatever we can do to aid it improves the entertainment. It is possible to show quite reasonable animated pictures on wall-paper, but instead we use silvered screens suitably framed and edged with black. For the same reason, therefore, we should mask our loud speakers.

CHAPTER VI

SOUND-ON-DISC EQUIPMENT

The two main divisions of talking picture apparatus, namely, sound-on-disc and sound-on-film, have already been discussed, and these will be adopted in description. At the present moment there are many more sound-on-disc equipments than sound-on-film, although in the future possibly the conditions may be reversed.

Perhaps the best method of dealing with the question of sound-on-disc is first to describe the essentials of the apparatus, and from this the features of manufacturers' equipment follow naturally.

The Essentials. When talking pictures first became commercially popular the early equipments were known as "Attachments." The existing projector was pressed into service and all the exhibitor had to do was to purchase an attachment for coupling to his apparatus. Any attachment system is naturally more economical than the purchase outright of an entirely new equipment including projector. Furthermore an attachment is necessarily more simple, since we are dealing for the most part with parts with which we are already familiar.

Let us now examine again the essentials of a sound-on-disc projector. Briefly we can list them as below—

1. The projector.
2. The sound system.
3. The turntable.
4. The synchronizer.

Nothing need be said about the projector except that since it is to be used for sound pictures it will have to be reasonably silent. Some of the better-class projectors run reasonably quietly, and can actually be silenced more by attending to some of the items mentioned in a later chapter. In professional work, of course, the noise of the projector itself is immaterial, since it is housed aside from the

auditorium in the operating box. For home purposes, however, in most cases the projector and screen and, of course, the audience are in the same room, therefore much noise cannot be tolerated.

"Sound system" is purposely worded in a vague manner to include the use of the acoustic gramophone. Many people aver that the ordinary acoustic or horn type gramophone is useless from the point of view of amateur talking pictures. This, however, in the opinion and experience of the present writer, is by no means the case. The sound system consists of some means of magnifying or reproducing sound already recorded on commercial discs—amplifier or sound box and horn.

The turntable is a mechanical essential for rotating the record, and may or may not be associated with the sound system.

Lastly we have the synchronizer, the function of which is to couple together the projector and the turntable. As mentioned previously this synchronizer may be mechanical or electrical, but for our present purpose we shall confine ourselves to mechanical synchronizers.

Let us suppose we wish to set up a home talking picture equipment with the least possible expense. We have a projector operated by an electric motor. The type does not matter very much providing that it is in good condition and fulfils the stipulation of reasonable silence. We will further suppose that we have a sound system of an amplifier and loud speaker, quite possibly a radio set.

The next item is the turntable, and here we encounter a difficulty. This turntable may be on a portable gramophone or a cabinet type radiogram. In the latter case probably the loud speaker and amplifier are together with it in the same cabinet. In any case we shall find the turntable revolves at 78 revolutions per minute when the governor or speed regulator is set in the mean position. Practically all talking picture records at present run at $33\frac{1}{3}$ revolutions per minute. On first thoughts there would appear to be a simple solution—altering the speed regulator so that it was brought down to $33\frac{1}{3}$ revolutions per minute. However, the governor on an ordinary gramophone will not

regulate to a speed as low as this, and even if it would the power would thus be cut down to such an extent that the record would not turn. Then again another point is that talking picture records are frequently 16 in. in diameter, and they would not fit on the ordinary gramophone simply because the pick-up arm is pivoted too close to the centre of the turntable. We shall, therefore, have to scrap our turntable or seriously modify it, always providing we intend to run standard records at $33\frac{1}{3}$ revolutions per minute.

There is, however, another solution to the problem, and that is to fit a specially designed turntable which, by internal gearing, will, when fitted to the spindle of an ordinary gramophone motor, reduce the speed to $33\frac{1}{3}$ as required. A device of this character was described in Chapter IV. It is satisfactory but does not, of course, eliminate the difficulty of the pick-up arm being too short.

If we are interested chiefly in making our own talking pictures then we shall probably do better at the start by running records at 78 or 80 revolutions per minute, since this gives better recording under normal conditions. For the time being, however, we will assume that we must get a new turntable.

The next point is the synchronizer. By some means or other we have to couple the turntable with the projector. There are several obvious ways of doing this. If we are purchasing a new turntable then naturally we shall obtain one possessing the necessary fitments.

Fig. 47 shows diagrammatically the arrangement of a disc talking picture projector. Looking first at the turntable which rotates at $33\frac{1}{3}$ r.p.m. we find that its shaft is geared to another at right angles which, through the medium of a flexible shaft, is connected to one of the continuously running sprockets of the projector. A flexible shaft usually consists of a number of strands of thin steel wire twisted together to form a flexible but strong medium which is then encased in a wound steel tube packed with grease. The crude method of driving by means of bevel gears straight to the turntable spindle shown in the diagram would not in all probability be adopted in practice, and is shown here for simplicity.

Even with this simple arrangement, however, some type of gear-box is necessary. The turntable rotates at 33⅓ r.p.m. while if the continuously running sprocket wheel of our projector is of the four picture variety it will run at 360 r.p.m. when the film is passing through the gate at a speed of 24 pictures per second, which is sound picture standard. This means to say that the gear-box must change

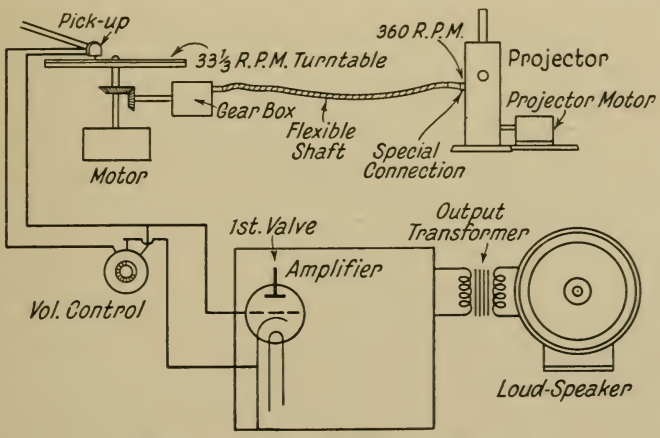


FIG. 47. SOUND-ON-DISC PROJECTION

or rather balance the speeds of rotation of turntable and projector.

The projector has an electric motor, and the turntable another, although this may, of course, be of the spring driven variety. How do the two function? Surely we cannot possibly have them running together? This is something like the old problem of the two locomotives coupled together one being a trifle faster than the other. Which one did the work? This arrangement is in practice quite satisfactory providing both motors are good and the turntable suitably governed. What happens is that the flexible shaft locks both mechanisms together, and they move as one being regulated by the governor. In passing it may be mentioned that it is wise not to take too great an advantage of the

flexible shaft. In other words, although a flexible shaft will function when bent considerably, it is far better to keep it in line as much as possible to avoid possibilities of irregular running.

Reverting to the electrical side of the question there is a pick-up differing not essentially from those used in electric gramophones and radiograms except that its length of arm is sufficient to allow it to work over a 16 in. disc. This pick-up arm is then connected through a volume control of the potentiometer type to the amplifier. Sometimes it is found coupled to one side of the grid to the input valve and the other to the cathode, as shown in the sketch. Sometimes, on the other hand, an intervening transformer is better, but this is a question of electrical design, and outside the scope of the present book, and will not, of course, occur if the amplifier belongs to a radiogram or has been used for gramophone reproduction.

From the output valve of the amplifier the circuit goes to the speaker. If of the moving coil class, there will be an output transformer as shown in the diagram.

The Reylik-attachment Equipment. Probably one of the simplest equipments on the market for enabling one to set up a home talking picture apparatus is the "Reylik," as shown in Fig. 48. The turntable is mounted on a base to the right of which is seen projecting the flexible shaft drive which is attached to the appropriate driving sprocket of the projector.

On the base is a volume control the operating knob of which can be seen to the left. If a radio set is employed and does not possess "pick-up" terminals an adaptor, as described in Chapter II, may be used. If the first valve of the amplifier happens to be also the detector of a radio set adequate changes must be made to the grid bias as also described in Chapter II.

A further point in connection with the use of grid bias batteries is that if the pick-up is left connected after the amplifier has been cut off, the grid bias battery will normally discharge. To prevent this a condenser may be inserted. Usually a capacity of ·1 μF. will be found about right, although actual trial should be made. Condensers

larger or smaller than this will affect volume or quality of sound.

In the Reylik attachment there is no motor, and thus that of the projector drives also the turntable. Models of the Reylik are now available in which the turntable speed can be changed from 78 r.p.m. to 33⅓ r.p.m. and *vice versa* by

(A. W. Green, Esq.)

FIG. 48. "REYLIK" HOME TALKIE ATTACHMENT

the simple movement of a gear change lever. This is a great advantage since it enables ordinary gramophone records to be played as accompaniment to silents, or alternatively, if we have made any records ourselves at 78 r.p.m., these may be played on the same turntable in synchronism with the film. It is possible to obtain from Messrs. Reylik (A. W. Green, Esq.) a suitable amplifier and, incidentally, this same attachment is provided in another form for recording talking pictures, as discussed in Chapter IX. The Reylik is provided for operating with both 9·5 mm. and 16 mm. projectors, there being no essential difference in the working.

Sheldon-Wilkinson Synchro-Gear. While on the subject of attachments we must not omit to mention the Sheldon-Wilkinson Synchro-Gear which, priced at 35s., is probably the cheapest talkie device existent. It is shown assembled

Fig. 49. Sheldon-Wilkinson Synchro-Gear

to a Kodatoy in Fig. 49, where it will be noted that it is coupled up to a Columbia portable gramophone, and possesses a home recorder.

An examination of the photograph shows that the synchronizer consists of a straight shaft coupled direct to the upper or feed sprocket of the Kodatoy, which passes along to a gear-box held on a flat plate at the side of the gramophone to which it is attached by means of wood screws. From the gear-box is a flexible shaft which curves to the top of the turntable spindle and is attached thereto by a type of collet.

The record is placed on the turntable, and the collet grips the projecting portion of the turntable spindle.

This particular device is intended primarily for playing home-made records but can, of course, be employed for ordinary sound-on-disc providing the record runs at 78 r.p.m.

We shall later discuss the use of the acoustic machine for use in amateur talking pictures, and at the present moment will pass by this adoption. The synchro gear is undoubtedly home talking pictures at their cheapest, and naturally the results obtained are not comparable with those of the higher priced sets manufactured by Messrs. Sheldon-Wilkinson or other firms. Although the illustration shows a 16 mm. Kodatoy connected to the gramophone attachments are available for 9·5 mm. projectors.

Incidentally, anyone contemplating a purchase of this or an attachment of similar type and desirous of using it in connection with standard gramophones should make sure that the length of projecting spindle is sufficient to provide a grip for the collet of the flexible shaft. Gramophones vary considerably with regard to the length of spindle, but if this happens to be too short it is a simple matter for an extension piece to be attached by a mechanic.

Unit Equipments—British Talkatomes. It is not quite fair to say that unit equipments are the next stage in sound-on-disc, since we can buy a complete projector, a turntable synchronizer, amplifier, and loud speaker all especially designed for the purpose. It may be a distinct economic advantage to maintain separate units in preference to a complete and self-contained projector equipment. Probably the most notable British set manufactured on the unit plan is that of Messrs. British Talkatomes. This company provides the complete range of sound-on-disc talking picture equipment except that they do not manufacture a special projector. Fig. 50 shows the turntable unit which is marketed at the price of 25 guineas, and is designed for playing standard 16 in. $33\frac{1}{3}$ discs, although a later model enables the speed to be changed to 78 r.p.m. The unit does not contain a motor, but the speed is maintained constant by means of the governor and damping arrangement. This

Fig. 50. British Talkatomes Turntable Unit

latter is particularly necessary when using $33\frac{1}{3}$ r.p.m. discs. To the front of the case on the right-hand side there are two control knobs. One for volume and the other for tone control after the fashion of radio sets and radiograms. A pilot lamp seen to the left of the case is provided for

setting the pick-up needle at start mark. The flexible shaft projects to the right-hand side of the case in the illustration, and is detachable for convenience in transport.

This turntable unit is readily portable, and the case shuts up completely and presents the outward appearance of an ordinary attaché or suit case.

Besides the turntable unit British Talkatomes, Ltd., supply also a mains-operated amplifier, a speaker screen, and a blimp or silence cabinet for the projector. The complete equipment is shown in Fig. 51, where the amplifier will be seen to the left, next the turntable unit, and the projector to the right. At the rear of the illustration is the speaker-screen.

The amplifier is of the two valve type, and has an output of 12 watts. The speaker-screen consists of the usual type of screen fitted in a readily portable case. At the back is mounted a moving coil loud speaker.

A point of interest in this equipment is that the amplifier is normally located near the turntable, and thus the length of pick-up lead from the pick-up to the input terminals of the amplifier is short. This is a definite advantage from the electrical standpoint, since it reduces the possibilities of hum and other interferences. In some equipments later to be mentioned we shall find a different arrangement. In practice it is sometimes possible to run one's pick-up leads for a considerable distance without encountering trouble. Nevertheless the principle of British Talkatomes is to be commended.

In the photograph the projector is shown open to the view. Under most circumstances, however, it will be found desirable to encase this in a sound proof blimp which is also supplied by Messrs. Talkatomes. Even the best of "silent" projectors are somewhat too noisy for talking picture work, although as a matter of fact when one becomes absorbed in a picture one does not readily notice a relatively loud noise. This by the way is usually from the point of view of the audience and not the operator, who is painfully conscious of the whirr of the sprockets.

In passing it may be mentioned that the company in question have built a library of subjects, amongst which are

Fig. 51. British Talkatomes Complete Equipment

numbered many featuring popular screen favourites. It is understood also that the company hope to be producing films themselves in the near future. A constructor's "kit set" for making a synchronized turntable is the latest addition to this company's products, and is offered at an attractive figure.

The Bell & Howell Filmophone Portable Sound Equipment. The name Bell & Howell has long been associated with what is best in cinematograph equipment, and this company was one of the first to appreciate the possibilities of 16 mm. sound-on-disc, and placed apparatus on the market soon after the talking picture achieved popularity.

In America the development of 16 mm. talking pictures was associated directly with salesmanship and advertising and, therefore, the question of portability was of paramount importance. The first sound equipment produced by Messrs. Bell & Howell was known as the Project-O-Phone, and consisted of three distinct units. First was the projector, and second the turntable unit with an individual motor also containing the amplifier. The last was the loud speaker itself of the moving coil type. These three units were each packed in special carrying cases. The amplifier was of the two stage variety employing one UX226 valve as first stage with a push-pull output of two UX112A valves. The turntable motor was of the induction type.

With this equipment the flexible shaft did not act as a driving member, but simply locked the turntable motor and the projector motor together. The speed of the two running as a unit was controlled by the turntable governor, although naturally the resistance on the projector would be suitably set. In normal working the brake on the projector was entirely released, and a special type of projector motor running at a speed of 6,500 revolutions per minute was provided so that the projector should match the turntable.

This equipment was designed in the first place to operate on a 110 volt A.C. supply—the American standard—but for D.C. purposes a converter was obtainable. The use of a converter makes no difference whatsoever to the functioning of the various parts of the instrument. All that is done is to change direct current supply into an alternating one,

Fig. 52. Bell & Howell Film-O-Phone Equipment in Use

from which the equipment is fed. This is better than building separate equipment for working on direct current.

The next equipment developed was the Film-O-Phone, where the number of carrying cases was reduced to two—one weighing 50 lb. and the other 38 lb. The former carries the turntable, flexible shaft, pick-up, and amplifier, whilst the latter contains the loud speaker and projector together with connecting cords and cable, extra films, etc.

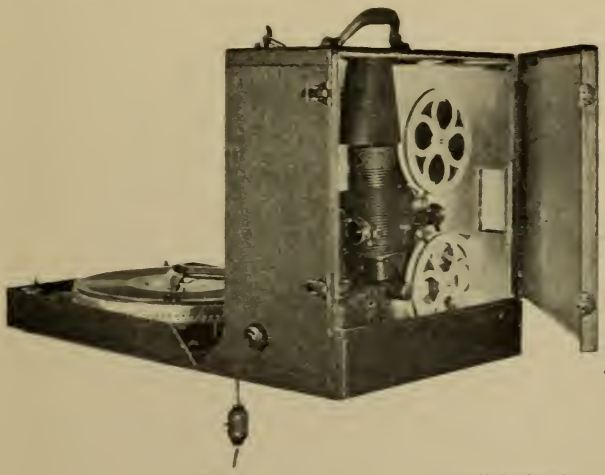
This equipment is seen in operation in Fig. 52, where it is in use for sales purposes. The projector on the right is coupled to the turntable and amplifier unit to the left, while in the background immediately beneath the screen is the loud speaker case. The main difference from the early model lies in the elimination of the extra motor on the turntable unit. Obviously this is a step in the right direction, for there is no reason for employing two electric motors within a foot or so of each other, which have to be controlled to be run at exactly the same speed—and precisely in step. A higher power motor from the projector now also operates the turntable through the flexible shaft. The amplifier in this model was changed so that only two amplifying valves were employed, one input and one output, with, of course, the usual rectifier valve. A further feature was introduced as illustrated in Fig. 53, where we see the operator giving a few words on the film subject over the microphone.

The microphone is a very useful adjunct to talking picture equipment. It can be used, for instance, to provide a running commentary on silent films or for interposing comments during a talkie. It will be appreciated that this is particularly valuable from the point of view of sales and advertising. Thus suppose the talking picture portrays an expert mechanic fitting a new type of piston ring to an engine saying, "Now watch carefully as I place the scraper ring over the top of the piston." Here the salesman operating the projector interposes through his microphone quickly, "That's the one I showed you at lunch time." Amateurs will be able to devise many little tricks of the microphone for home entertainment.

The modern "Blimp Film-O-Phone" contains many improvements. The outstanding feature is that the projector

FIG. 53. BELL & HOWELL EQUIPMENT—USING THE MICROPHONE

is now permanently mounted in operating position in a sound proof blimp as mentioned when speaking of British Talkatomes in the earlier part of the chapter. Fig. 54 shows the unit, where it will be observed that the projector is fixed in a carrying case which has a slot cut for the beam. The turntable unit is also contained in the same case and



(Bell & Howell)

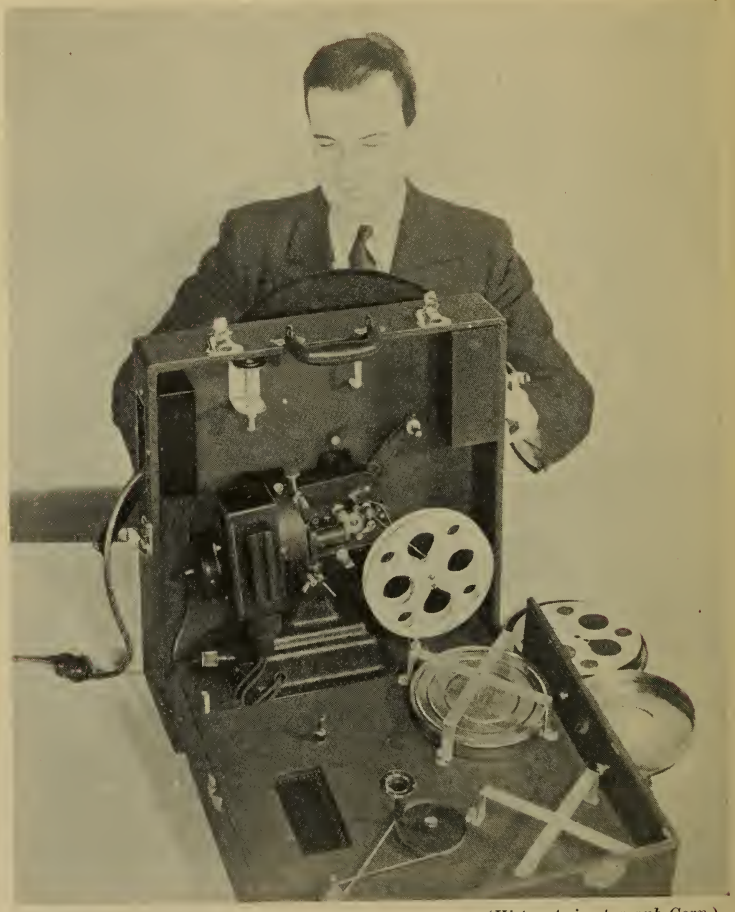
FIG. 54. THE BLIMP FILM-O-PHONE

opens as a lid into the flat position shown. Tone and volume controls are also on this unit.

Twin loud speakers are fitted to cover the whole band of audible frequencies, and the amplifier has been relegated to the loud speaker case and now possesses pentode valves which give a higher degree of amplification. Spare films, etc., are carried in the loud speaker unit.

This particular model lends itself to continuous programmes. Two blimp type projector turntable units may be used with one loud speaker, and the sound switched from one projector to the other by means of a fader or double action volume control.

The price of the Bell & Howell Blimp Film-O-Phone equipment is 415 dollars, plus the price of any particular



(*Victor Animatograph Corp.*)

FIG. 55. THE VICTOR ANIMATOPHONE

film projector desired, plus 15 dollars for a modification for flexible shaft driving. The whole equipment is, of course, supplied complete, but as there are a number of types of Bell & Howell projectors any one of them may be chosen.

The price is, of course, high, and probably prohibitive to many talking picture enthusiasts. The one thing to remember, however, is that with this equipment we can give an entertainment on a par with finest theatre quality.

The Victor Animatophone. The Victor Animatophone is an American home talkie which follows lines similar to those adopted by Messrs. Bell & Howell. It is essentially a portable, and has been adopted by many of the large companies in America for advertising purposes. The Victor Animatograph Corporation state that their first market lies with religious, educational, and industrial bodies, although they are by no means forgetting the requirements of the home. They expect that the 16 mm. sound projector will quickly replace the silent machine for educational purposes. It is to be remembered that the cinematograph has for some years been firmly established as an educational feature in America.

Fig. 55 shows the projector and turntable unit in their blimp. The projector in question is of the standard "Animatograph" type as marketed in Great Britain by Messrs. Dallmeyer. The arrangement of the turntable is unique. Examination of the illustration indicates that the operator in the background is facing a 16 in. disc which projects above the case. The discs run vertically and not horizontally as is the usual rule.

Fig. 56 shows how this takes place. It is an easy matter to run a disc vertically, but more difficult to ensure that the pick-up or, rather, needle makes proper contact with the grooves. The pick-up is fitted to a balance arm which is connected through a swivel joint to a rocker. The combined movement of the two permits the balance arm to travel in a straight line from the centre of the record outwards. Theoretically this is a better movement than the usual radial arm which, of course, introduces errors as were mentioned in the first part of the book. The Animatophone is also fitted with hand type microphone after the style of the Bell & Howell, and possesses a gear for $33\frac{1}{3}$ or 78 r.p.m. Another ingenious feature is the pilot lamp—which, normally flush with the case, pulls out and at the same time illuminates, thus providing a source of light for setting the needle to start mark.

The needle point is kept in contact with the surface of the record by the balance arm which, acting as a pendulum, keeps the needle constantly applied to the groove. This is a case of gravity acting through a lever and not direct, as in the case of the standard type of pick-up.

The Ampro 16 mm. Sound System. Another American high-class sub-standard sound-on-disc projector is the

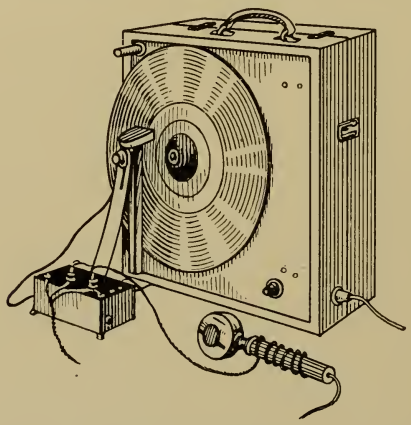


Fig. 56. Turntable Arrangement of Victor Animatophone

Ampro, a product of the Ampro Corporation of Chicago. The equipment consists of two units, the first of which contains the projector and turntable, and the second the loud speaker, amplifier, spare reels of film, and a number of discs.

The drawing in Fig. 57 shows the equipment, where it will be noted that the turntable unit, although carried in the same case as the projector, is detachable and is connected to the projector by means of the usual flexible shaft. Only one motor is employed, namely that of the projector, which is of adequate power to drive both machines. It is of the constant speed or synchronous type, and has been especially designed for standard American electric supply, namely 100 to 125 volts and 60 cycles A.C. In this country

we rarely employ this particular type of motor owing to the fact that our electricity supplies vary so much. In the future, however, when the new electric schemes are complete it is probable that these motors will be adopted generally. The synchronous motor is such that it keeps in step or to a speed proportional to that of the main generator at the power supply station. A governor is not necessary

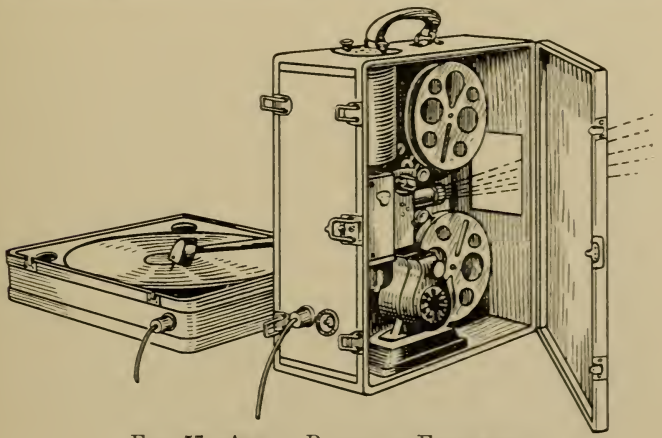


FIG. 57. AMPRO PORTABLE EQUIPMENT

and, indeed, would completely spoil the operation of the motor. Incidentally we may mention the parallel case of the synchronous electric clock.

One of the features of the Ampro equipment is its flexibility to speed ratios, which render possible any combination of $33\frac{1}{3}$ or 80 r.p.m. discs with 16 and 24 pictures per second. Projector and turntable can be run independently.

The amplifier supplied with the Ampro sound system is a very large one, capable of filling a medium-sized hall.

The case carrying the loud speaker and amplifier has sufficient accommodation for carrying six reels with their appropriate discs, and the usual perquisities of the operator, film cement, menders, etc. The Ampro system also possesses a hand type of microphone with a separate volume control which can be operated independently of the pick-up in the

turntable. In using a microphone in the same room as the loud speaker care has to be taken as otherwise "howl" takes place. The best method of preventing this is to turn the volume control as low as possible, and speak close to the diaphragm, which should have its back towards the loud speaker at the screen end. It is for this reason that the Ampro microphone is fitted with separate control.

The Sheldon-Wilkinson Portable Talkiephone. While on the subject of portable disc equipment we cannot fail to mention the Sheldon-Wilkinson apparatus as shown in Fig. 58, which is entirely different in principle from those previously mentioned. As a matter of fact the apparatus illustrated combines the dual functions of projector and recorder, enabling one both to take and show one's own talkies. We shall, however, be dealing with this aspect of the question in greater detail later on, and thus for the time being shall mention only those features used for projection. The Portable Talkiephone is essentially a projector attachment, although it is entirely self-contained and portable, taking no more space than a rather heavy portable gramophone. One of the unique features of the equipment is that the turntable is driven by a spring motor and not an electric one. Synchronism between the projector and the turntable is obtained by means of the usual flexible shaft.

The loud speaker seen in open lid is detachable, and can be placed near to, or behind, the screen in the usual manner. The equipment is, we believe, available for use with either 16 mm. or 9·5 mm. projectors of all types. The flexible shaft shown is used also for connection to a camera when recording amateur talking pictures, and beneath the loud speaker is the microphone. The case also contains a two valve portable amplifier operated by batteries. This is another feature for in all other equipments mentioned, mains operation has been the rule.

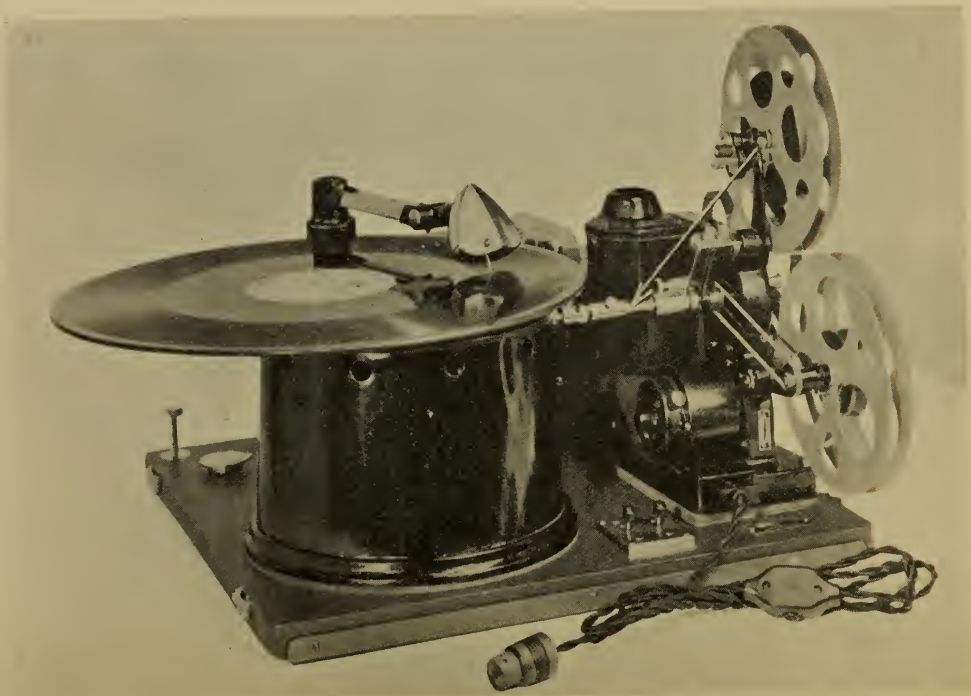
When reviewing a variety of equipments as we are now doing we have to bear in mind that 16 mm. film can be used for several entirely different purposes. Thus equipment such as that of Messrs. Bell & Howell, although eminently suited for home projection, can if necessary be used in a hall of large proportions.

The Sheldon-Wilkinson apparatus, however, is of a different nature, and is designed primarily from the point of view of the amateur. The price of the portable or suitcase Talkie-

FIG. 58. SHELDON-WILKINSON PORTABLE TALKIEPHONE

phone illustrated is 25 guineas, excluding, of course, projector and camera. This price includes the turntable unit, amplifier, pick-up (used also as a recorder), and microphone and loud speaker.

The Bolex-Paillard Home Talkie. The name Bolex is



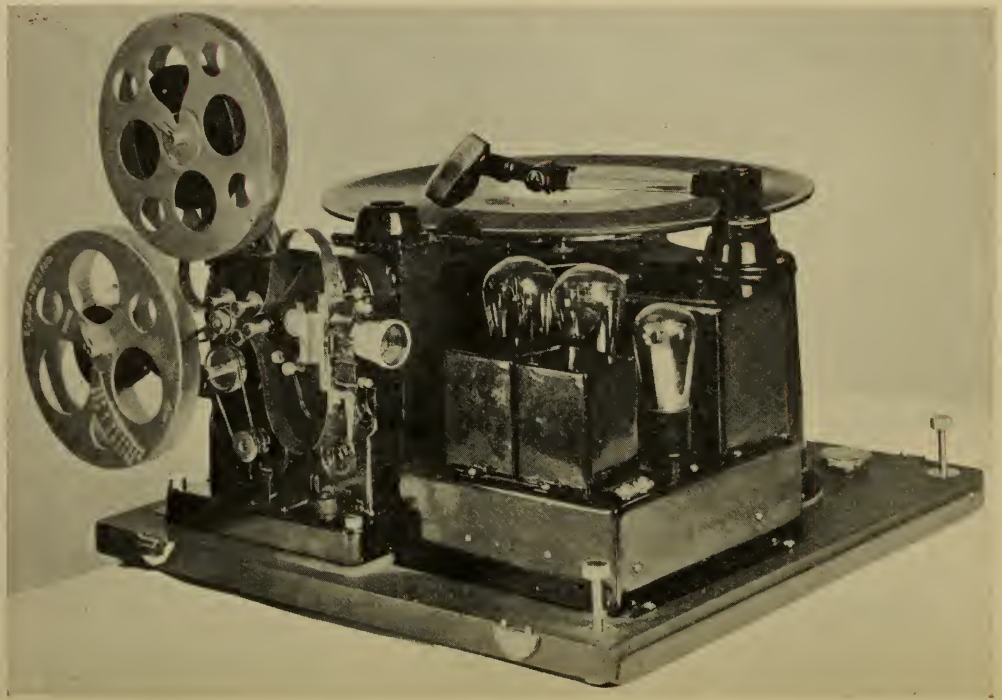
(Cinex, Ltd.)

FIG. 59A. BOLEX-PAILLARD EQUIPMENT

well known to cinema amateurs as the projector capable of showing both 16 and 9·5 mm. film. Equally well known is Paillard in the gramophone industry, particularly in connection with motors. A combination of the two should be interesting. Fig. 59 shows the complete unit with, of course, the exception of the loud speaker. The apparatus cannot well be classed as a portable, although it is neat and compact. In the opinion of the writer it is certainly one of the best efforts at producing talking picture equipment for home purposes. The projector itself is fitted with a 250 watt air-cooled projection lamp providing adequate illumination for its screen up to 10 ft. wide. The lens is the well-known Hugo Meyer "Kinon" F/1·6, and the illumination provided is excellent. This, however, is aside the main subject. The apparatus, therefore, is capable of giving home entertainment or for a small hall.

The unique feature, however, is the method of maintaining synchronism. No flexible shaft is employed nor is there any rigid member connecting projector to turntable. The Bolex-Paillard is the first apparatus mentioned so far utilizing electrical synchronization. Two motors are employed, one on the projector and the other the turntable. They are kept in step by an ingenious device which can be seen pointed out by the arrow in Fig. 59.

The turntable is capable of rotating at 78 or $33\frac{1}{3}$ r.p.m., but these speeds are definitely set by the makers, and not capable of alteration by ordinary means. Governing of the projector motor is accomplished by the turntable. The manner in which this is obtained is very simple, and is illustrated diagrammatically in Fig. 60. Here we have two screws or threaded shafts A and B. A is connected to the motor of the turntable, and B to the motor of the projector. Mating with both of these is a nut C. A little consideration will show that if these screwed shafts A and B turn in the same direction at precisely the same speed the nut C will turn with both of them, but will not move backwards or forwards along their axis. Should, however, either A or B speed up or slow down then immediately nut C will move one way or the other. Now as we have already stated the speed of shaft A is carefully governed, and by the turntable



(*Cinex, Ltd.*)

FIG. 59B. BOLEX-PAILLARD EQUIPMENT

motor. The problem, therefore, is to harness the projector screw *B* to *A*. This is accomplished by the projecting arm *D* which when it moves in a direction parallel to the axis of the screwed shafts *A* and *B* touches or releases the electrical contacts at *E*. These are coupled across a resistance *F* in series with the projector motor. If, therefore, the speed of *B* changes, as it is always tending to do, either the arm *D* closes the contacts *E* or releases them according

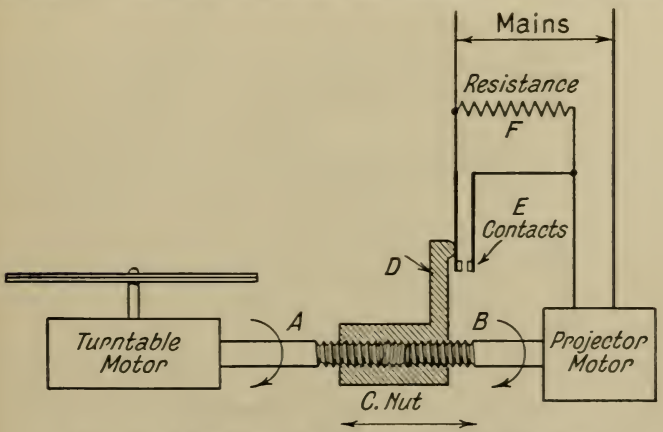


FIG. 60. PRINCIPLE OF BOLEX-PAILLARD ELECTRIC SYNCHRONIZER

to which way the variation lies. This means that the resistance *F* is either cut in or out of the electrical driving circuit of the projector motor which changes the speed. The cycle of operations is continuing all the time, and the projector motor constantly rising and falling in speed. The action takes place so quickly, however, that the fluctuation is not apparent, and a uniform average turning is obtained.

On first consideration this might seem an imperfect method of attaining synchronism, and not to be compared with the rigid coupling of the flexible shaft. As a matter of fact, however, it possesses distinct advantages. We are aware that speed constance of the turntable of a gramophone or talking picture apparatus is of much greater importance

than that of a silent projector. By considering a talking picture equipment as a combination of both gramophone and projector we fall into the somewhat natural error of thinking that the projector in this case must always move with perfect uniformity. This, however, is not the case. Every picture on the film must definitely correspond to a certain point on the grooves of the record we are playing. How it attains that position does not concern us greatly. For the sake of argument we might imagine a projector in which the picture changes occupied different intervals as we went along due to some imperfection in the mechanism. So long as this imperfection was not transmitted to the turntable we might still get perfectly synchronized talking pictures. As a matter of fact, in Chapter X we describe an apparatus working on somewhat unique lines which utilizes this principle, though in an entirely different manner from that of the Bolex-Paillard.

Reverting to our main subject we can state that a projector is a veritable nuisance when connected mechanically to a turntable. By this we mean that on one hand we have a turntable which must rotate with perfect uniformity, and on the other a mechanism, the projector, which essentially works intermittently with a varying load on the mechanism and, therefore, the tendency to fluctuate. Most talking picture apparatus overcome this difficulty by fitting damping arrangements and fairly long flexible shafts, the object of which is to take out unevenness transmitted by the projector motor. Bolex-Palliard, however, treat the matter differently. Their turntable is governed uniformly and through it is the projector harnessed. In the Bolex machine it does not matter really if the projector mechanism is worn or running somewhat erratically. It is absolutely essential that mechanically coupled projectors be kept in first-class condition and free from all minor inaccuracies and vibrations. The Bolex-Paillard apparatus does not seek to even out imperfections of the motion of the projector, it simply adds an apparatus which renders them harmless. Loss of synchronism can be corrected during running by adjustment to a screw which varies the relative position of the parts corresponding to the arm *D* and the contact *C*.

This is the first apparatus we have mentioned so far which permits adjustment of synchronism while the apparatus is working. Actually such adjustment should never be used, for in any case it is deplorable operating to permit a picture to start out of synchronism.

Returning to the description of the apparatus, the turntable and projector are combined on a single base with an amplifier which is of the three valve type the two output

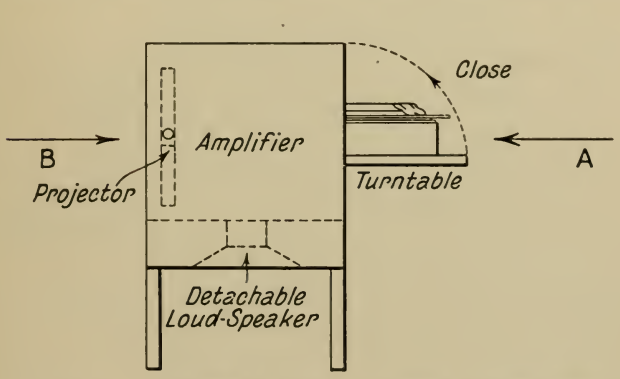


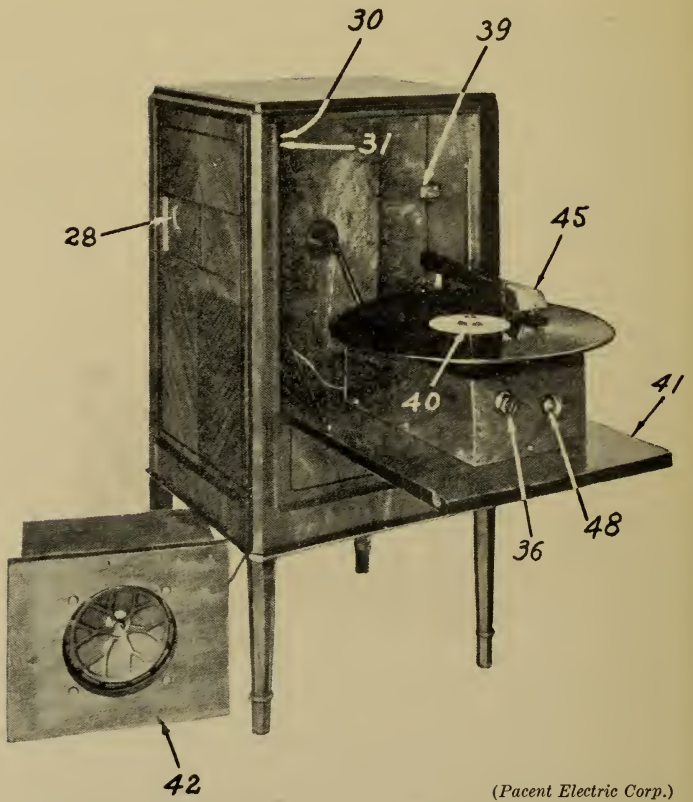
FIG. 61. DIAGRAM OF PACENT CABINET ARRANGEMENT

valves being in push-pull. The loud speaker provided is a moving coil one.

The projector itself runs at either 24 pictures per second or 16 while the turntable revolves at 78 r.p.m. or $33\frac{1}{3}$. Another advantage of the apparatus is that the motors of the projector and turntable are individually controlled so that either machine can be used alone or with the other.

Another interesting feature of the projector is that it is not necessary to project the start mark on the screen, since there is a small reflecting mirror provided on the projector for this purpose. Finally, the apparatus can, of course, be used with either 9·5 or 16 mm. film. This, we think, will probably prove to be of even greater advantage with talking pictures than with the old silent ones.

Altogether the Bolex-Paillard home talking picture



(Pacent Electric Corp.)

FIG. 62. PACENT CONSOLETTE EQUIPMENT—TURNTABLE SIDE

28. Port Hole
30. Amplifier Power Supply Switch
31. Pilot Lamp
36. Turntable Speed Change Knob
39. Pickup Clamp
40. Record Clamping Nut
41. Drop Door
42. Dynamic Speaker Unit
45. Magnetic Pickup
48. Drive Mechanism Rotating Knob

apparatus is a thoroughly good job, and is not expensive even at its price of £100 when one considers that it is absolutely complete.

The Pacent 16 mm. Home Talkie Equipment. Up to the present we have dealt with attachments and portable

equipments. We now come to the first of a different class in which the whole equipment is housed in a cabinet consolette. The home talkie equipment thus becomes like a modern radio, a piece of furniture and not simply a mechanism. To a good many people this type of construction will have greatest appeal.

The outward appearance of the No. 750 consolette home talkie is that of an ordinary radiogram, with the exception that one misses the familiar fret of the loud speaker at the

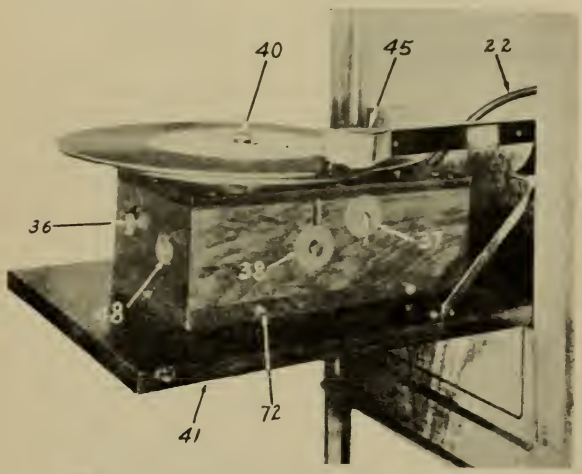


Fig. 63a. Pacent Equipment—Turntable

front of the cabinet. The mechanism and details of the Pacent equipment are similar to those employed in several other types of equipment already described, but the arrangement is entirely individual, presenting a number of unique and useful features.

Fig. 61 is a line diagram showing the disposition of the various parts of the Pacent Consolette. Here we find amplifier, projector, turntable, and loud speaker from the front of the cabinet. One of the unique features of the apparatus is that the complete turntable unit drops into the position shown, although normally it is closed in an upwards

direction as is indicated by the dotted arrow. A view of the right-hand side of the cabinet looking in the direction of arrow *A* is shown in Fig. 62, where the various parts are numbered. To the left of the cabinet will be seen the loud speaker unit No. 42, which is a standard dynamic moving coil type. An interesting feature about the arrangement in the Pacent apparatus is that although normally the loud

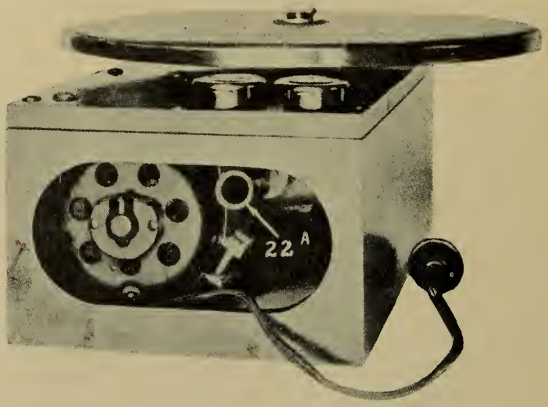


Fig. 63B. Pacent Equipment—Turntable and Motor Unit

speaker is housed at the bottom of the cabinet it can easily be removed and taken to the screen end of the room, thus providing necessary illusion.

Fig. 63A shows the turntable on its drop door in more detail where it will be seen that the entire driving mechanism, including synchronous turntable and pick-up, is fixed to a heavy, wooden door which lifts upwards and folds flush with the side of the cabinet when not in use. When lowered it appears as in the illustration, and houses a heavy type motor with a governor and gear-box. This latter presents a coupling marked 22 *A* in Fig. 63B, which shows the turntable and motor unit as mounted within the wooden well, as in Fig. 63A. The flexible shaft from the projector is simply plugged into socket 22 *A* when connection is complete. The Pacent Phonovox electric pick-up No. 45 at *A*

is held back by a clamp No. 39, Fig. 62, before the turntable unit is folded upwards. The Pacent apparatus is capable of showing pictures at 24 pictures per second and 16

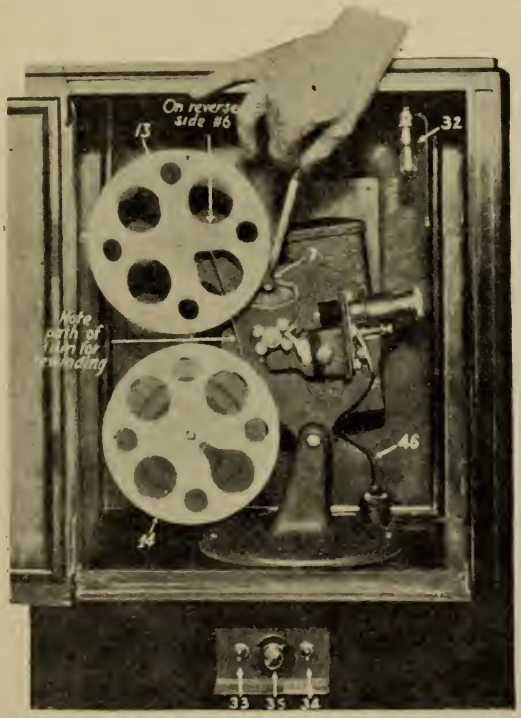


FIG. 63C. PACENT EQUIPMENT—PROJECTOR SIDE

6. Upper Rewind Belt	14. Lower Film Spool	33. Motor Switch
7. Film Rewind Knob	32. Film Thread Lamp	35. Volume Control
13. Upper Film Spool	46. Projector Lamp Cable	34. Projection Lamp Switch

pictures per second, with or without synchronous discs turning at speeds at both $33\frac{1}{3}$ and 78 r.p.m. Either projector or turntable unit amplifier and loud speaker can, if necessary, be used separately.

The gear shift knob No. 37 in Fig. 63A is used for changing projector speed from 24 to 16 frames or pictures per second

at will. It has a neutral position in which the projector is inoperative, and the turntable and pick-up may be used for records at $33\frac{1}{3}$ or 78 r.p.m.

The change from $33\frac{1}{3}$ to 78 r.p.m. speed of the turntable or *vice versa* is made by the speed change knob No. 36 in Fig. 63A, while the regulator No. 38 is used for setting the turntable speed accurately at either of these speeds.

Reverting now to the projector side of the apparatus at *C* we find that it is working totally enclosed so as to reduce noise to a minimum. For this same reason the internal surfaces of the cabinet are lined with sound absorbent material. When the apparatus is working the light beam issues from a small port hole No. 28. To facilitate setting the projector in a dark room a pilot light No. 32 at *C* is provided. At this side of the equipment are three controls, the motor switch No. 33, the volume control No. 35, and the projector lamp switch No. 34. The usefulness of the arrangement of these various controls will now be appreciated. When first of all we set up the apparatus for whatever purpose we have in hand—talking pictures, silent or accompanied silent, we lower the turntable drop door gently into position, and make the correct adjustment to the turntable speed change knob No. 36 and the projector speed change lever No. 37. It we wish to check the turntable speed we should do so by means of the usual stroboscope disc, probably making adjustment by the motor speed regulator No. 38.

We now come to the other side of the machine and thread our film by means of the pilot lamp—this will be found sufficient to locate the start frame. Correct position in the gate takes place by turning a knob seen just below the objective and slightly to the left in *C*. Checking that the start frame is exactly in the gate can take place simply by switching on the projector lamp for a moment.

We now return to the other side of the machine, and after selecting the appropriate record, place it on the turntable after first removing the clamping nut No. 40 at *A*. The pick-up arm is removed from its rest position and a needle is inserted in the pick-up. The needle is then set to the inner start mark towards the centre of the record.

Now by closing switches 33 and 34 in *A* we start the motor operating both turntable and projector and arc in the projector lamp. Volume can then be adjusted by knob

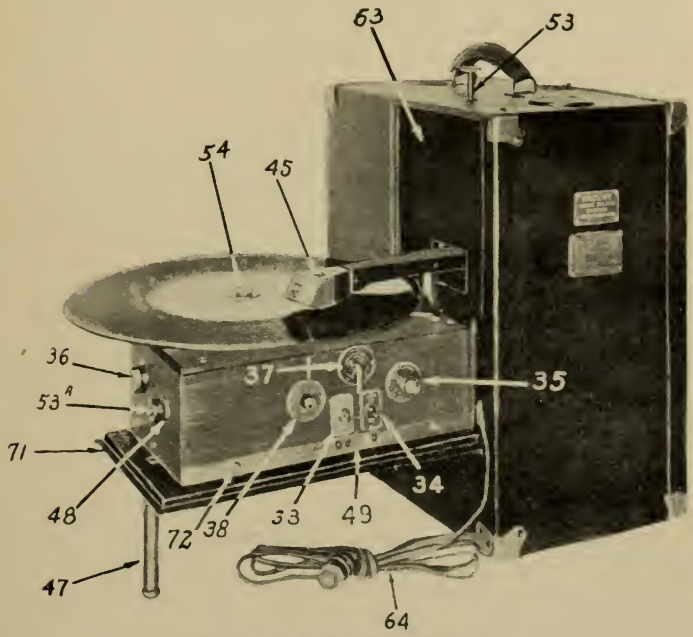


FIG. 64A. PACENT PORTABLE

33. Motor Switch
34. Projector Lamp Switch
35. Volume Control
36. Turntable Speed Change Knob
37. Projector Speed Change Lever
38. Motor Speed Regulator
45. Electro-magnetic Pick-up
47. Leg Stand
48. Drive Mechanism Rotating Knob
49. Voice Line Pin Jacks
53A. Socket Flange
53. Drop Door Locking Screw
54. Record Clamping Nut
63. Sound Partition
64. Power Supply Cable
71. Drop Door
72. Motor Box Retaining Screws

35. Under normal conditions of operating we should be standing to the projector side of the cabinet, thus having under our control the three essential points. We are likely to want to adjust volume several times during a normal entertainment, and should anything go wrong the first thing

would be to cut off the motor and projector lamp. Both these controls are ready to hand. There is a separate switch to the amplifier to the position shown at No. 30 in Fig. 63, and this would naturally be broken if we were showing unaccompanied silent films.

Pacent Portable Equipment. The Pacent portable equip-

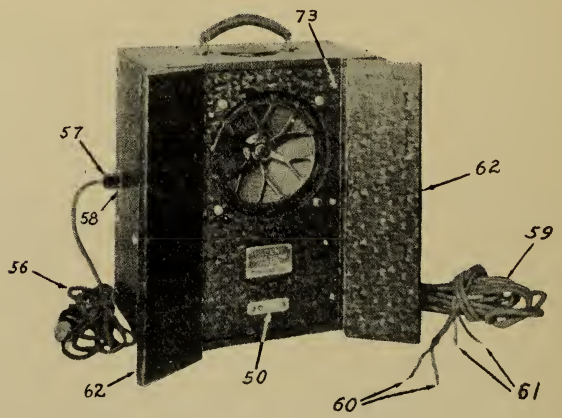


FIG. 64B. PACENT PORTABLE LOUD SPEAKER UNIT

50. Voice Line Pin Jacks	58. Plug Receptacle	61. Pin Tips
56. Power Supply Cable	59. Voice Cable	62. Baffle Doors
57. Power Supply Cable Plug	60. Pin Tips	73. Baffle Retaining Screw

ment, so far as construction is concerned, is identical with the consolette model already described. Two carrying cases are employed, one housing projector and turntable, and the other loud speaker and amplifier. The feature of the drop type of turntable is retained, as will be seen by Fig. 64A, which shows the side of the apparatus equivalent to that of Fig. 63A of the consolette model, with the exception that in this case we find that the motor switch No. 33, the projector lamp switch No. 34, and the volume control No. 35 are now incorporated.

The various other details of the apparatus are shown in the table at the bottom of the illustration. The other carrying case is shown at *B*. Plugs and jacks are provided for rapid connection of the various wires. It will be noted that

for operating the portable equipment two sources of power are required. The cable No. 64 at *A* provides the supply to the motor operating turntable and projector, while loud speaker unit is fed from another connection No. 56 which provides the supply to the amplifier and field of the loud speaker. The two units are coupled by means of another

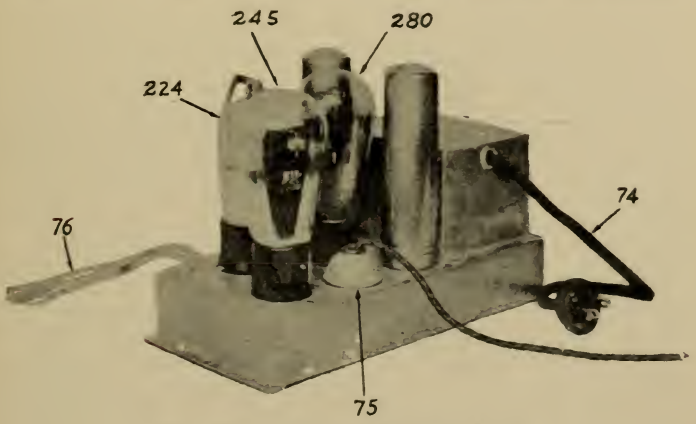


FIG. 64C. PACENT AMPLIFIER UNIT

224. Screen Grid Vacuum Tube Type '24
245. Output Vacuum Tube Type '45
280. Full Wave Rectifier Tube Type '80
74. Amplifier Power Cable
75. Speaker Cable Plug
76. Amplifier Input and Battery Lines

cable No. 59, which is transmitted to jack No. 49 at *A* to corresponding jack No. 50 at *B*.

The amplifier used with the Pacent equipment is compact as shown at *C*, the design employs a 224 screen grid valve operating into a 45 output, from which it will be gathered that the equipment, although providing adequate volume for the largest sized room, is not intended for hall purposes. In their tables of picture size and distances from the screen the Pacent company mention 9 ft. 7 in. as the biggest picture which is obtained from a 1 in. focal lens at a distance of 25 ft. from the screen. This we should imagine would be about the maximum for the equipment, bearing in mind the size of the amplifier.

The prices of the equipment are by no means high

considering the construction and detail, and the complete consolette No. 750 with projector, pick-up, turntable, amplifier, and loud speaker costs 275 dollars. Following a common American practice valves are not included in this price. The No. 751 consolette without amplifier and loud speaker is 230 dollars, while the complete portable equipment costs 205 dollars for the unit containing the pick-up, turntable, and projector, and 65 dollars for the portable amplifier and loud speaker.

Synchrophone Cabinet Equipment. The Synchrophone is probably the most ambitious disc apparatus manufactured in Great Britain. In one cabinet are combined the functions of a talking picture apparatus, a mains radio set, an electric gramophone, and a silent projector of special design intended to reduce running noise to a minimum. Messrs. Synchrophone were one of the few manufacturers who tackled the noise problem of the so-called "silent" projector from the right angle by designing a projector with a new type of mechanism which did not create noise. In various other types of apparatus blimps have been employed to keep the noise from affecting the room in which the entertainment is given. In the case of the Synchrophone, however, noise is prevented at its source, a measure which if successful is obviously better than sound proofing. At least six of the teeth of the sprocket wheel engage in the film at any given moment, thus reducing the possibility of tearing the perforations of the film. The whole mechanism operates without reciprocating parts, and this to a certain extent simplifies lubrication, always a neglected point with apparatus of this type. Gears, etc., run in grease-tight boxes and under normal conditions should run for a number of years without needing attention.

Fig. 65 shows the arrangement of the various sections in the cabinet. At *A* we have what is styled the Synchrophone face where the lid is closed and beneath it is the outline of the projector. Lower still are four drawers for carrying film cases, and at the bottom a rack for discs. At *B* we see the wireless face of the cabinet where the control knobs are visible just above the fret over the loud speaker. At *C* is the lens face which is actually that looking in the direction of

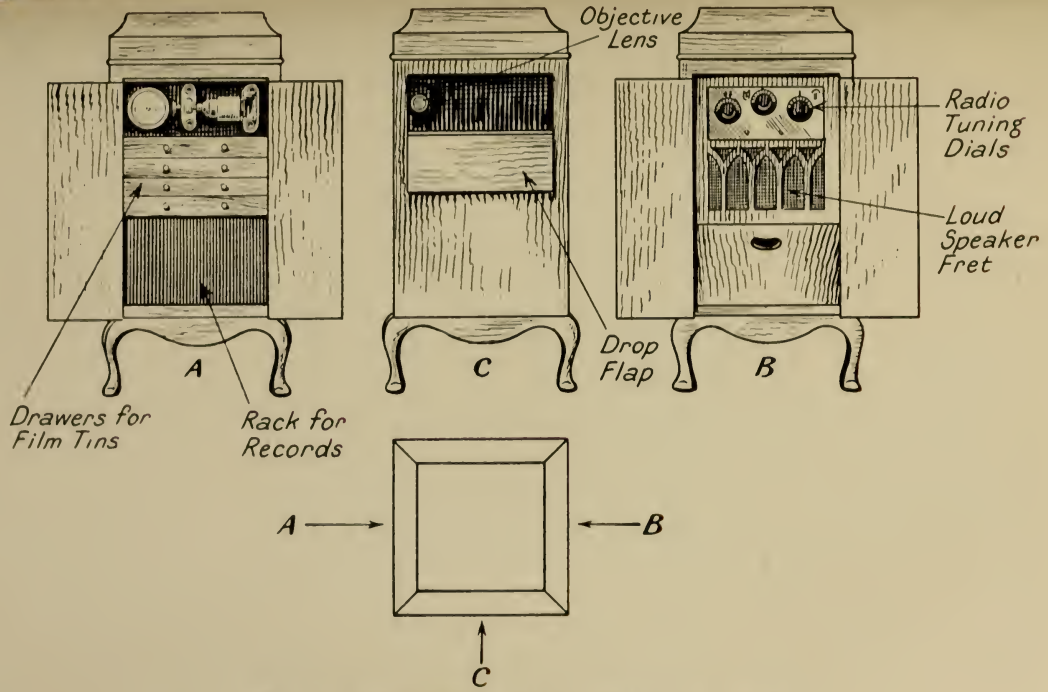


FIG. 65. ARRANGEMENT OF SYNCHROPHONE CABINET

the arrow in the illustration *A*. The drop flap shown marks the porthole through which the projector beam issues. The complete Synchrophone cabinet is shown in Fig. 66.

The Synchrophone possesses contrasting features to the Pacent equipment previously described. The turntable, for instance, in this case is in the regular position as found in radiograms, namely at the top of the cabinet, and is accessible by the usual type lid. Here we find change-over switches from wireless to Synchrophone, needle boxes, and a clutch control from projector to gramophone. Volume control and turntable speed control are also located there.

A change-over switch is provided so that the sound from the amplifier can be thrown at will either through the internal loud speaker or an external one situated near the screen. Two loud speakers for a combined set of this type is an advantage.

Various models of Synchrophone are available ranging from the cheap model in oak costing 50 guineas without wireless set and utilizing an acoustic horn. This is an interesting model in so far as this is the second instrument we have noted so far where the acoustic gramophone is used for home talkie picture work. Naturally its scope is more limited than the electric models, and furthermore the illusion can never be so good since the sound cannot issue from the same place as the picture. Several other models are available in mahogany and walnut with complete radio sets as mentioned previously. The originally designed Synchrophone was intended for use for records running at a speed of 78 r.p.m., but the new model caters for both $33\frac{1}{3}$ and 78 r.p.m.

It is interesting to note that Messrs. Synchrophone have prepared a series of library subjects, and furthermore undertake the recording of films for amateurs, and for this purpose have equipped studios in London. The prices for recording are extremely reasonable, and are, we believe, in the region of 5 guineas. Arrangements have been made also for library subscriptions for synchronized films and records.

As we shall mention later when dealing with some general aspects of amateur talking pictures, we cannot help but feel that there are two distinct fields for work. First of all there

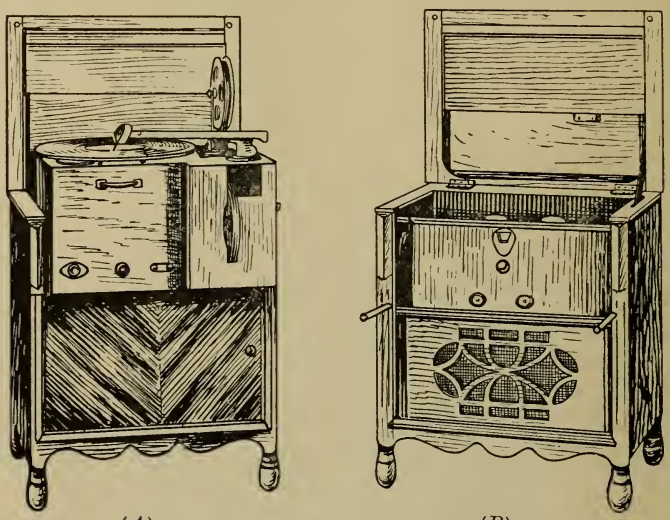
is the 33⅓ r.p.m. record with its accompanying film, both of which may be taken and adapted from standard theatre

FIG. 66. SYNCHROPHONE CABINET SOUND-ON-DISC EQUIPMENT

supply. At the present moment in the silent world much of the 16 mm. and 9·5 mm. film sold and rented out from libraries has been printed down from the original 35 mm. stock as screened in the cinema theatres. We shall,

therefore, in the amateur talkie world have a supply of subjects corresponding to these silent ones.

But the amateur talking picture opens up a field for itself, and this may well employ records running at a speed of 78



(*A*) (*B*)

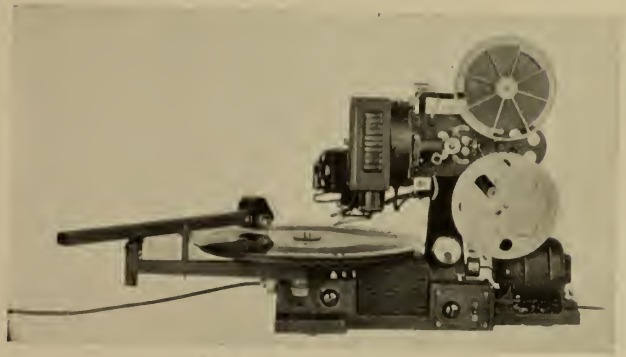
FIG. 67. PATHEGRAMS 9·5 MM. EQUIPMENT

(*A*) Projector and Turntable Cabinet
(*B*) Amplifier Radio Loud Speaker and Screen Cabinet

r.p.m. with relatively short length of film, and it is here that Messrs. Synchrophone may score heavily against some of their competitors. The new model Synchrophone will deal with pictures synchronized to either 33⅓ or 80 r.p.m. records. So far this is no more than has been done by other manufacturers, but Messrs. Synchrophone go further than this, since they have prepared a number of subjects at 80 r.p.m.

Pathegrams 9·5 mm. Equipment. The Pathegrams equipment is designed exclusively for 9·5 mm. film, and is of the cabinet type in a new form. Particular interest is attached to this production, since Messrs. Pathegrams Inc., of New York, have probably the largest home talking picture

16 MM. SOUND DISC EQUIPMENT



16 MM. DISC PROJECTOR

COMBINED SPEAKER AND AMPLIFIERS

FIG. 68. 16 MM. SOUND DISC EQUIPMENT.

library in the world, consisting of hundreds of up-to-date full length subjects printed down from standard film.

Fig. 67 shows the two cabinets which house the Pathegram apparatus. That at (*A*) contains the turntable and 9·5 mm. projector which are driven direct by a double field governed motor, no flexible shaft being used. When the cabinet lid is lowered turntable and projector sink flush, and the cabinet assumes normal appearance. At (*B*) is the other cabinet containing loud speaker and amplifier, and providing support for a 4 ft. screen. The amplifier is included in the circuit of a 7 valve superheterodyne radio set. The volume provided is adequate for a small hall with a seating capacity of about one hundred persons.

Thus we see Pathegrams equipment consists of two cabinets placed at opposite sides of a room, and connected only by wire flex which can be concealed. Everything is always ready for working, yet always concealed. The arrangement from the point of view of home entertainment is ideal. Cabinet (*A*) costs 185 dollars and (*B*) 75 dollars, less valves.

Western Electric 16 mm. Disc Equipment. Fig. 68 shows the 16 mm. sound-on-disc equipment of the Western Electric Co., which company did much of the work involved in the development of the talking picture itself, equipping the major part of the film industry. The 16 mm. apparatus is on a parallel with their 35 mm. as regards quality, but the price is high, as might be expected. Two cases accommodate the equipment, the projector and turntable being combined into one unit, and the amplifier and loud speaker into another, as seen in the lower illustration. The construction is robust, and it is possible that an equipment of this type may become standard for educational work if the position is not usurped by sound-on-film equipment as described in the next chapter.

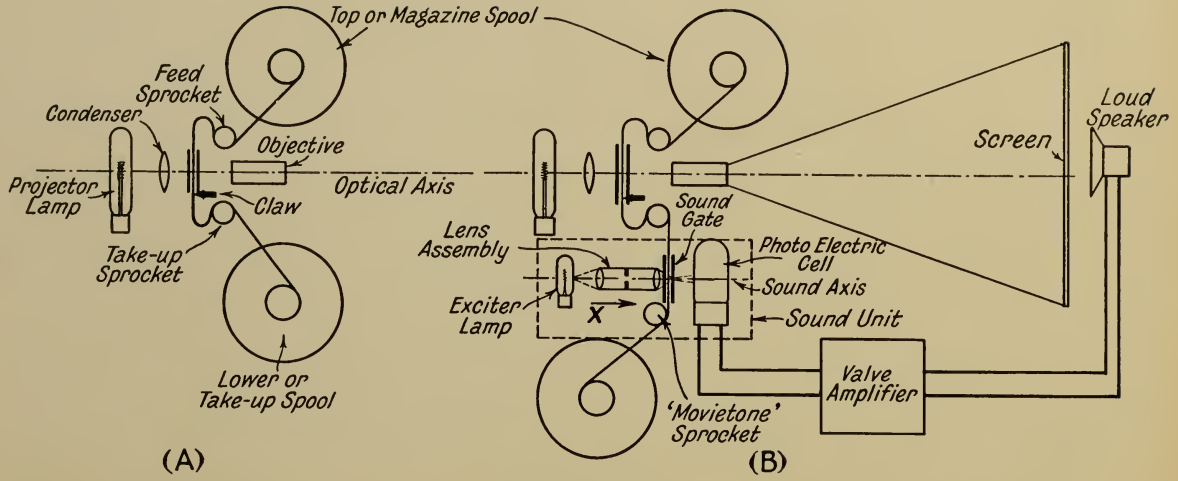
CHAPTER VII

SOUND-ON-FILM EQUIPMENT

We now come to the second method of reproducing synchronized sound and picture. Referring to Chapter V, Fig. 42, we note that the sound track on the edge of the film is converted into audible sound by means of a thin beam of light and photo-electric cell. This thin beam of light is interrupted by the film sound track, and thus more or less light falls upon the sensitive surface of the photo-electric cell, which causes voltage fluctuation which is impressed upon the grid of the first valve of an amplifier. We must now consider the matter in greater detail before we treat of the apparatus.

The first question we are likely to ask is, "Where and in what manner is this special photo-electric cell equipment fitted to the silent projector?" We should imagine it might possibly be a type of attachment after the style of the sound-on-disc equipment previously discussed. To understand this better look at Fig. 69, where at (*A*) we see a diagrammatic lay-out of an ordinary silent projector. Here we have the film carried by the magazine spool passing over the feed sprocket, through the gate, over the claw of the intermittent mechanism, then to the take-up sprocket, and finally to the lower spool.

At (*B*) we have a similar arrangement, but between the take-up sprocket and the lower spool we find a further arrangement generally known as the "sound unit." The film after leaving the take-up passes through what is known as the "sound gate," which in general construction is somewhat similar to the ordinary picture film gate, in so far as it consists of a means of holding the film flat. From this sound gate the film passes another wheel which has become known as the "movietone sprocket"; thence it passes to the lower spool, where it is rewound in the usual manner. At the sound gate we have another optical system somewhat similar to the larger one for picture projection. Here we find an exciter



FIGS. 69A AND B

(A) Silent projector. (B) Attachment of sound unit

lamp which emits a bright light which is collected by a lens assembly which throws an extremely fine beam of light on to the sound gate, through the sound track to the photo-electric cell, which is coupled to an amplifier and loud speaker.

Perhaps it is not yet quite clear how the sound gate functions. Let us, therefore, examine (C) which shows in a schematic manner the sound gate looking in the direction of the X in diagram (B). For our purpose we can consider the face of the sound gate as consisting of an opaque material in which is cut a small slit which corresponds in position with the sound track on the film. It is on to this slit that the fine beam from the lens assembly is projected, and passes through it to the sound track and thus to the photo-electric cell. The actual width of the beam of light falling through the slit is in the region of one thousandth of an inch or less, and is actually made as fine as possible consistent with brilliancy of illumination.

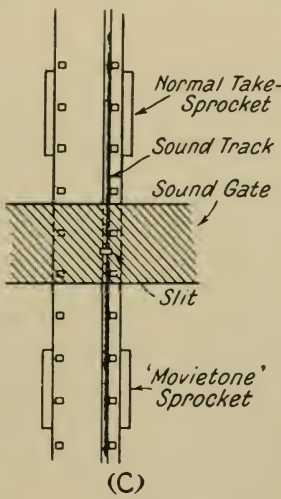


FIG. 69c
Position of Sound Gate Slit

A little consideration will show that the width of this light beam corresponds to the point of a gramophone needle in the disc method of reproduction. The highest frequencies which can be reproduced from a gramophone record depend to a large extent upon the smallness of the point of the needle, simply because if the needle has a blunt point it cannot follow round some of the fine curves of the sound wave. So it is with sound-on-film, and obviously the light beam cannot pick out frequencies having peaks smaller than its own width. There are naturally a good many mechanical variations of the details shown at (B) and (C) in Fig. 69. Thus, for instance, the positions of the photo-electric cell and the exciter lamp might easily be reversed.

One point which we must stress is that the length of film running before the sound gate and between the exciter lamp and the photo-electric cell is moving continuously, and not in jerks as before the ordinary picture gate. More than this, it is of paramount importance that the film between the normal take-up sprocket and the "movietone" sprocket moves with perfect uniformity and freedom from all types of fluctuation. A little thought will indicate that the movement of this part of the film corresponds to the turning of a gramophone record. To this end various attachments are provided for damping vibration and the like, and it is common to fit the movietone sprocket with a heavy flywheel. In some apparatus the movietone sprocket is very similar in construction to the usual sprocket wheels encountered in projectors. In others, notably the R.C.A. to be described later, it consists of a plain drum, the idea being to prevent that slight jerkiness usually associated with toothed wheels.

R.C.A. Photophone Portable 16 mm. Sound-on-Film Projector. Much of the pioneer work of the professional talking picture was carried out by the Radio Corporation of America and associated companies. It is not surprising, therefore, that this same company was one of the earliest to introduce the 16 mm. or non-theatrical sound-on-film projector.

The equipment itself consists of two units in case form which are shown together in Fig. 70. One of these contains the projector and amplifier, and appears in the foreground of the photograph. It is $14\frac{1}{2}$ in. long, $13\frac{1}{2}$ in. high, and $8\frac{1}{4}$ in. wide, and weighs 43 lb. The other case contains the loud speaker, and is 19 in. long, 16 in. high, and $9\frac{1}{2}$ in. wide, and weighs only 21 lb. Space is provided in this case for the storage of 8 reels of film of 400 ft. length. It will be gathered immediately that for portability this equipment compares very favourably with some of the sound-on-disc equipments already dealt with. It may appear somewhat strange that in this, the most modern development of amateur talking pictures, the amplifier has been kept close to the projector and not placed with the loud speaker, as appears to be the tendency with the disc equipment. The reason is that the

speech current from the photo-electric cell which is of necessity associated with the projector is of such small value that a long lead cannot be entertained. This means that we must have the first valve close to the photo-electric cell, as otherwise we shall very likely pick up interference. Naturally, therefore, for portable equipment, if we must have one valve

FIG. 70. R.C.A. 16 MM. PORTABLE SOUND-ON-FILM EQUIPMENT

close to the projector, we might just as well place the remainder there.

The projector itself, shown in Fig. 71, is neat and compact as might have been expected from the size of the carrying case. Let us trace the film from the feed reel to the take-up reel which it will be noted are attached outside the carrying case. The projector is not removed from its case during entertainment, one side being open for threading, after which it is closed again to reduce projector noise. From the feed reel the film passes through a slot in the side of the cabinet to the feed sprocket, and thence through the usual film gate at the back of the optical system. Below the top film loop

is the projection lamp which is of the 100 watt type. From the projection optical system the film passes over a pressure roller, then round the sound drum over another idler roller, an impedance roller and back to the take-up sprocket reel.

The exciter lamp housing is shown to the right of the sound drum, and between it and the sound drum is the

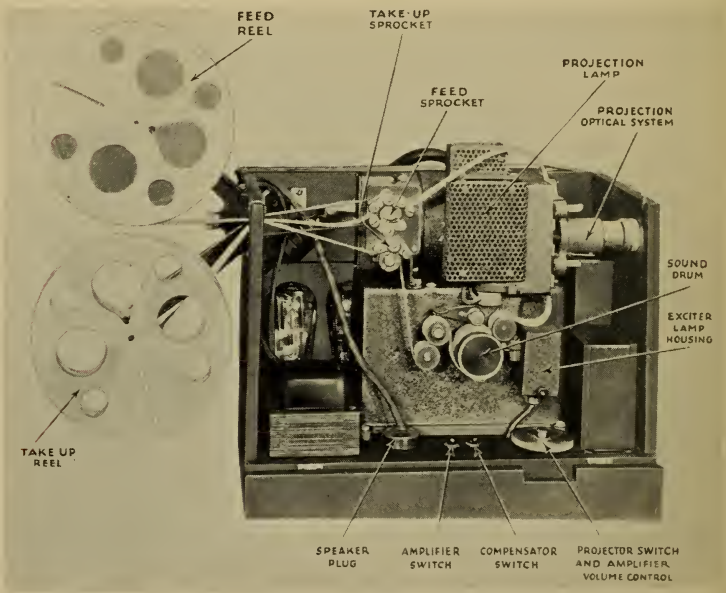


Fig. 71. R.C.A. 16 mm. Sound-on-Film Portable Projector

projection of a casting which carries the lens assembly. We look in vain for the photo-electric cell, and the arrangement of this is one of the ingenious features of the equipment.

The optical sound system of the R.C.A. portable is shown diagrammatically in Fig. 72A, where there is an exciter lamp, sound optical system, and photo-electric cell as in our diagram Fig. 71. Instead of the thin light beam passing direct through the sound track on the photo-electric cell

in this case it strikes a mirror, and from this is reflected to the photo-electric cell. This makes no difference whatsoever in the functioning of the apparatus, but merely provides for convenience of fixing the photo-electric cell. In the case of the R.C.A. equipment we have the light beam passing from the exciter lamp through the lens assembly, and the edge of the film carried round the sound drum. Inside the sound drum is the small reflecting mirror carried on a bracket, and from this the modulated light beam is thrown

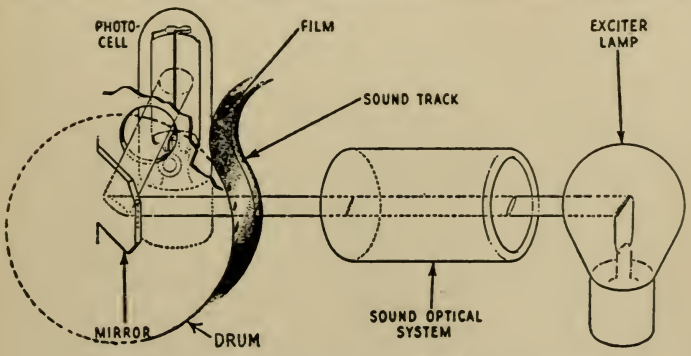


Fig. 72A. Optical System of R.C.A. Equipment

on to a photo-electric cell carried within the main casting, and not visible in the illustration. It should be mentioned that the sound drum is somewhat different in construction from what it appears in the illustration, and is cut away so that the light beam passing through the sound track is unobstructed.

The difficulty with 16 mm. sound-on-film is that there is little space available for the sound track. In R.C.A. system this has been overcome by utilizing a film with perforations down one edge only after the style of Fig. 72B, where it will be seen that the space usually allocated to one set of perforations has been completely utilized by the track. The size of the picture remaining is precisely the same as that in ordinary silent 16 mm. films.

The function of the pressure roller is merely to hold the film snugly against the sound drum, and of the idler roller

to give the film the right direction, and to bring it into sufficient contact round the sound drum. The impedance roller maintains a damping effect tending to eliminate jerkiness.

Adjustment of Sound Optical System. We are all acquainted with the methods for focusing the usual optical system, although some projectors are pre-set. Obviously the sound optical system requires even more careful treatment, since the slightest adjustment will affect reproduction because amplification of sound is vastly greater than that of picture. There is no common unit with which to express this difference, but we must always bear in mind when dealing with sound-on-film that the amplification of the electrical impulses generated by the light falling upon the photo-electric cell is enormous, and even when we become accustomed to handling the equipment we cannot but wonder at this marvel wrought by science.

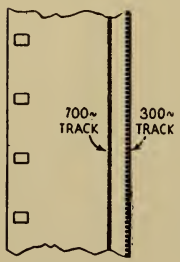


Fig. 72B
R.C.A. 16 mm. Sound Film—Buzz Track

It is evident that the start of quality lies with the exciter lamp as any variation in its intensity will be transmitted through the system, and appear as unwanted noise in the loud speaker. It will be remembered that many troubles were encountered in radio amplifiers before the indirectly heated valve became common. These were due to the fluctuation of "raw" A.C. Obviously, then, it would be out of the question to illuminate the exciter lamp merely by coupling it direct to the mains. In the R.C.A. equipment the exciter lamp is illuminated through the medium of a valve, and is actually operated by radio frequency current supplied by a UX 245 oscillator tuned to 15 KC, so that voltage variations are beyond the audible limit. This is a neat way out of the difficulty, and is comparable in principle to our modern non-flick shutters. Early cinematograph pictures flickered owing to the use of the shutter, but nowadays we eliminate this simply by making them flicker so fast that the eye cannot discern it. So with the R.C.A. exciter lamp,

which is illuminated by a current alternating so fast that we cannot hear the noise produced.

The exciter lamp has to be set exactly in position so that it is normal to the axis of the lens assembly and in right focus. Suitable adjusting screws are provided on the mechanism and also special steel blocks for attaining alignment. The filament of the exciter lamp has, of course, to be parallel to face of the optical system or lens assembly.

Look now to diagram (C) of Fig. 69, where we show the sound track and sound gate. Obviously it is of paramount importance that due to the relative positions of sound gate and film the beam of light falls directly upon the track, and not in the slightest degree to one side or the other. If, for instance, the film was slightly over to the right in the diagram the beam of light would pass across the side of the picture which would modulate the light falling on the photo-electric cell in a most undesirable manner, and create through the loud speaker a noise somewhat resembling a squadron of aeroplanes running amok. The pressure roller shown in Fig. 71 is adjustable by means of the screw seen to its left, either forwards or backwards looking at the face of the illustration, and with it the film. To make this adjustment easier the R.C.A. provide what is known as "buzz track" film. The buzz track film, actually shown in Fig. 72B, is entirely different from the ordinary type of sound film in that it has two small sound tracks, each of which is outside the normal position of the track. That is to say, when buzz track film is running through the projector there should be no sound whatsoever if the light beam and film are correctly positioned in relation to one another. The two small tracks on the buzz track film have sound of different pitch, namely 700 cycles and 300 cycles, the former of which is high pitched and the latter low pitched. This means that if we run the test film through and hear a high pitched note the pressure roller must be moved outwards, and if we hear a low pitched note then it must be moved inwards.

AMPLIFIER. In Fig. 73 we show, by courtesy of the R.C.A., their wiring schematic of the junior portable. It is presented here because it exhibits certain unconventional features. In the case of sound-on-disc equipment we have

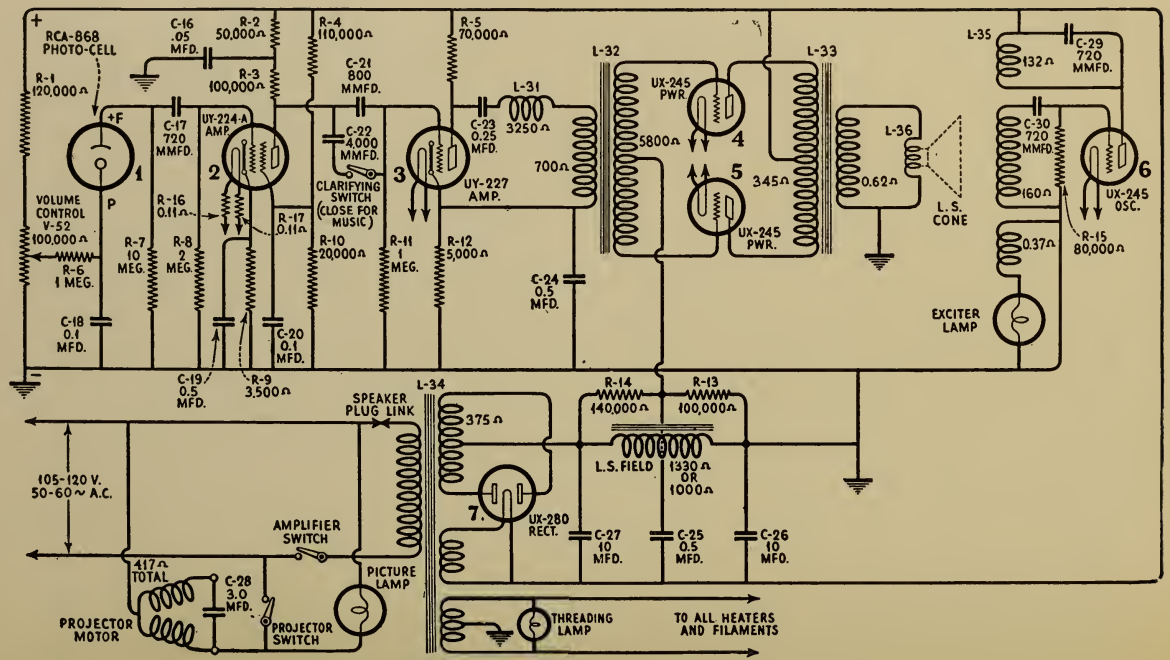


FIG. 73. CIRCUIT DIAGRAM OF R.C.A. EQUIPMENT

omitted mention of particular types of amplifiers, since these are commonly known in association with the ordinary radiogram or electric gramophone. An examination of the diagram shows that the projection lamp is operated direct from the mains, and also indicates the method of illuminating the exciter lamp. The light from the exciter lamp after passing through the sound track reflects upon the photo-electric cell and sets up voltage variations across the resistor in its plate circuit. A volume control is provided in the anode circuit controlling the output of the set. The photo-electric cell is coupled to the control grid circuit of the UY 224A voltage amplifier by resistance coupling.

From the UY 224A we go by means of further resistance coupling to the grid of the UY 227, which in turn is transformer coupled to a UX 245 push-pull power amplifier, connected to a moving coil loud speaker.

It will be noted that the coupling condenser between the UY 224A and the UY 227 is adjustable, providing for increase in low frequency output when desired. The undistorted output of the amplifier is approximately 3 watts, which will give some indication of the volume obtained from the set.

It will be noted that this amplifier is of the three-stage type, whereas with sound-on-disc two stages was the general rule, although sometimes the output was considerably higher than 3 watts. The reason for using a three-stage amplifier is that the output from a photo-electric cell is much lower than that from an electric pick-up or reproducer, and so an extra stage of amplification is necessary to bring it up to the same audible level.

The maximum recommended picture size is 52 in. wide, and from this it will be gathered that the Junior Portable falls within the home talking picture category, although naturally it can be used for small halls.

Re-recorded Sound-on-film. It might be thought that due to the fact that an entirely new standard of film is adopted in this projector, difficulty would be experienced in obtaining subjects. As a matter of fact, however, this is not the case, since the R.C.A. have produced re-recording apparatus by means of which both picture and sound

from standard 35 mm. subjects are printed on to the new type of 16 mm. film having only one set of perforations and with the sound track at the edge of the film.

At the time of writing the general tendency in the production of 16 mm. sound-on-film is always to re-record, from 35 mm. film. Frequently the process of re-recording takes place by optical means after the style of the reduction of standard size film to 16 mm., though naturally much greater care has to be expended. The advantage of this process for 16 mm. sound-on-film is that we get the reversed effect of a photographic enlargement. In other words, since we are reducing, the sharpness of the resultant sound track is greater than in the original.

Ordinary standard size sound-on-film runs at a speed of 24 pictures a second, which corresponds to 90 ft. per minute; 16 mm. sound-on-film also runs at 24 pictures per second, but this amounts only to 36 ft. per minute. As we explained earlier the range of sound frequencies obtainable is in a great measure proportional to film speed. Thus we cannot expect the quality of reproduction from 16 mm. film run at a speed of 24 pictures per second to be equal to that of the larger size film. This must be taken as a condemnation of 16 mm. sound-on-film which will eventually reign supreme as the amateur talking picture equipment. At the present moment it is perfectly certain that the quality of reproduction from 16 mm. sound-on-film running at a speed of 24 pictures per second is not equal to that given by discs. That this should be so is obvious, since for 16 mm., or 9·5 mm. film for that matter, we employ exactly the same discs as were used for standard size films, and thus get exactly the same quality of sound. In the case of sound-on-film, however, we have to make a smaller and thus limited sound track by optically reducing from 35 mm. to 16 mm. We get a better quality sound track, which partly makes up for the lack of speed of the films. As time goes on the quality of sub-standard sound-on-film will improve, as it did with the professional side.

While mentioning disc reproduction it should be pointed out that the R.C.A. junior portable can be supplied with an extension shaft, so that a synchronous turntable may be

employed. This makes the instrument available for use either with sound-on-film or sound-on-disc, and we believe it is the only commercial equipment so far using sub-standard film which is universal to this extent.

The B.T-H. 16 mm. Sound-on-Film Reproducer. The British Thomson-Houston Co. is one of the largest British concerns manufacturing and installing professional 35 mm. sound-on-film equipment, and thus their entry into the 16 mm. sound-on-film field is particularly interesting. The film employed is of a standard type, that is to say, it possesses both sets of perforations in contradistinction to the R.C.A. set just described. An illustration of the B.T-H. 16 mm. sound film is shown in Fig. 74, where it will be noted that the variable width or variable area style of recording is adopted, but the projector will function equally well with any type of sound track.

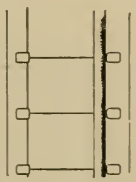


Fig. 74
B.T-H.
Sound Film

As with the Radio Corporation of America, the British Thomson-Houston Co. are for the moment concentrating on reproduction equipment, and film will be reduced from standard 35 mm. or from disc if necessary. This is to say that at the time of writing at all events, no commercial effort is to be made to market sound-on-film recorders of the 16 mm. variety. The soundness of this policy has already been mentioned, even while we naturally would like to see apparatus on the market whereby the amateur could, if he wanted, make his own sound film.

The actual size of the sound track is ·055 in. wide on a film 16 mm. (·63 in.). When it is considered that this is less than one-sixteenth of an inch one cannot help thinking it is remarkable that good reproduction can be obtained with such a small area to record the infinite variations of sound which occur in life.

Although the equipment has only recently been placed on the market it is the result of a number of years research. It was first shown at the Exhibition of Mechanical Aids to Learning at South Kensington in 1931, but between times various improvements have been incorporated, and the

equipment is at the time of writing at the production stage.

It is to be appreciated that the work of producing a sound-on-film projector, although fraught with difficulties, cannot be tackled until the even greater problem of obtaining a supply of films has been solved. As a matter of fact, there were several sound-on-film projectors available some time ago at reasonable prices, but a market did not exist for them since subjects were not available. Before putting their equipment on the market, therefore, the British Thomson-Houston Co. first made sure that they could obtain as many subjects as they required by simple reduction from 35 mm.

An interesting comparison of the properties of 35 mm. and 16 mm. sound film is given in a table prepared by the British Thomson-Houston Co. We give this below as it enables one to judge both the economic advantage of 16 mm. stock and at the same time appreciate the advance made by the coming of 16 mm. sound-film.

	35 *mm. Film*	16 *mm. Film*
	Inflammable.	Non-inflammable.
	900 ft. gives 10-minute run.	360 ft. gives 10-minute run.
	1,000 ft. weighs 5 lb.	Equivalent of 1,000 ft. of 35 mm. film weights 14 oz.
	A heavy metal case is required for transit.	Can be sent through the post.
Film speed ratio.	2–1/2	1·0
Film speed.	24 frames per sec. 90 ft. per min.	24 frames per sec. 35 ft. per min.
Width of sound track.	0·070 in.	0·055 in.
Width of picture.	0·895 in.	0·348 in.
Depth of picture.	0·748 in.	0·300 in.

The provisions of the Cinematograph Acts do not apply to the 16 mm. equipment, which can be used at any place and time, as required.

The Equipment. The B.T-H. apparatus consists of two units or three if we include the screen which is also supplied. The projector unit including the projector itself, sound unit and amplifier is $17\frac{3}{4}$ in. by 10 in. by $22\frac{1}{2}$ in. The loud speaker case, which in this instance also accommodates the mains

unit, has space for spare valves and photo-electric cells, is $17\frac{1}{2}$ in. by $9\frac{3}{4}$ in. by 20 in. The portable screen supplied is 50 in. by 40 in., and folds in a case 52 in. long by 4 in. square. The whole equipment is shown in Fig. 75, where the case containing the projector, amplifier, etc., is seen to the left, the loud speaker to the right, and the screen in the background.

Fig. 76A and B shows two views of the projector unit

FIG. 75. B.T-H. 16 MM. SOUND-ON-FILM EQUIPMENT COMPLETE

closed and open. In Fig. 76 we see that the spools are placed to the front of the projector instead of to the rear, as in the case of the R.C.A. equipment. To the left of the projector case is the mains unit which normally is carried in the loud speaker case, and is plugged into the projector before use. At 76B we see the same side of the projector but with the side thrown open exposing the mechanism. The projector is similar to the standard 16 mm. silents, but is capable of running quietly at the higher speed necessary for sound films.

In passing we may note that this is one of the dangers of

adaption of existing projectors to sound-on-film requirements. The writer carried out one or two experiments with projectors, and found that in some instances the increase in noise could be estimated at 300 or 400 per cent, always remembering that increase in volume of 100 per cent is just noticeable to the ordinary ear.

The projector is fitted with an adjustable gate mask so that silent films may be run if required. In Fig. 77 we see

Fig. 76a. B.T-H. 16 mm. Sound-on-Film Projector

why this is necessary. At (A) we have a strip of ordinary film running behind the gate aperture which is a cushion-shaped rectangle cut in metal of a size just sufficiently smaller than the picture to prevent the ragged framing showing on the screen. At (B) we have the same modified so that the sound track is not projected; although the aperture height will be the same, the width will be less. If we adapt an ordinary silent projector for sound work and make no change to the gate we shall project the sound track itself. This is certainly a novelty, but it soon wears off and becomes an annoyance. On the other hand, if we make the sound gate cater for sound films as in (B) we shall

have a strip of picture cut off if we project ordinary silent films. To overcome this difficulty we have the arrangement shown at (C) where the fixed gate is as for silent films at (A), but with the extra addition of a sliding mask shown by the cross hatching. Incidentally it may be remarked that

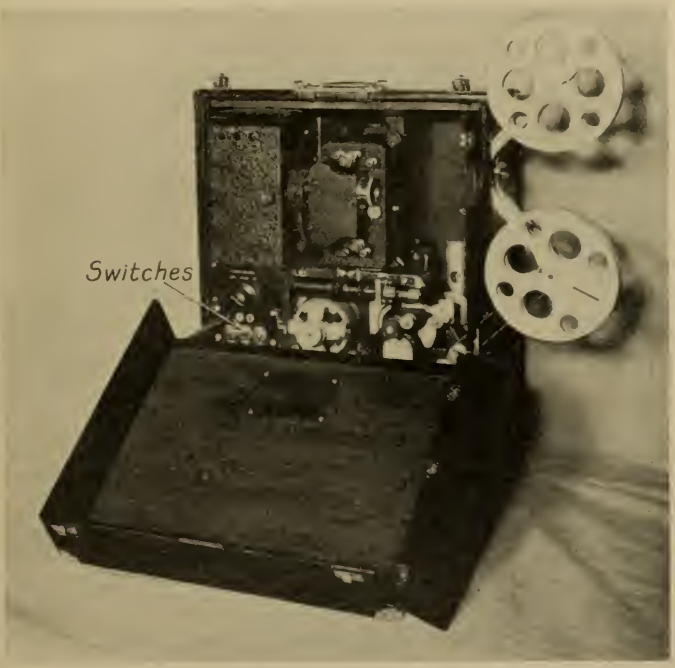


FIG. 76B. B.T-H. 16 MM. SOUND-ON-FILM PROJECTOR—OPEN

where sound-on-film equipment is also capable of being used for sound-on-disc the same necessity for a movable sound mask exists, since most sound-on-disc films are made full width.

The speed of the B.T-H. equipment is maintained constant by a mechanical governor. A great deal of work was necessary before adequate governing was attained, and as a matter

of fact in the early days of talking pictures one of the greatest troubles encountered was that of regulating the speed of film travel, so that pitch was constant. Looking again at the illustration at Fig. 76B we see the controls for the equipment are in a readily accessible position. The motor control switch, the amplifier projector lamp, and exciting lamp on and off switches as shown by arrows. Just below the motor knob we find two small sockets for the loud speaker leads.

In operation the projector unit is totally enclosed except for a small opening at the front through which the film passes.

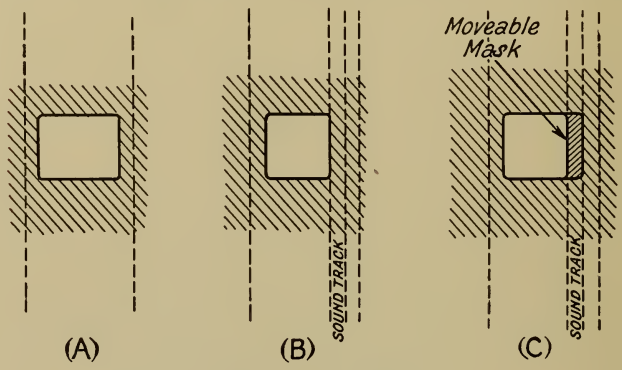


FIG. 77. GATE MASK

The volume control is situated to the lower part of the case below the opening lid, and is seen in Fig. 76A. This can be operated while the case is closed and the mechanism running.

The amplifier, which is of the three-stage type using the well-known Mazda valves, has an output of from $3\frac{1}{2}$ to 4 watts. The valves in question are of the indirectly heated type, and are fed from the mains by the mains unit, which incorporates an auto transformer with the usual voltage tapping panel which makes it possible to work the equipment from any supply of 50 cycles A.C.

It will be remembered that in the case of the R.C.A. equipment the exciter lamp was fed by a special oscillator valve so arranged that the periodicity was above audible limit. Here a different method is employed, and the exciter

lamp has a specially built filament of which the luminosity is practically constant irrespective of minor current changes. This principle is similar to that employed for indirectly heated valves.

If the equipment is to be employed on D.C. a small type of rotary converter is employed, such as is used for a similar purpose in electric gramophones and radiograms.

CHAPTER VIII

OPERATING NOTES

Operating Sound-on-Disc. It might be thought that since sound-on-disc is more simple in conception than sound-on-film it would be easier to work. This is not exactly true, although it certainly is easier to keep in running trim. We will suppose that an entertainment is to begin, and run over the various steps in operating.

There is a certain class of optimist who believes in the infallibility of mechanism. Of such is the man who jumps into his car on a winter's morning and presses the starter button, expecting the best. Others, perhaps more mechanically minded, take precautions and start slowly. It is not suggested that elaborate preparations should take place before every little entertainment, but the equipment should always be tested before a show. There is, it must be remembered, an artistic as well as a technical side, which must not be overlooked. After all, mechanism and electricity are simply means to an end, and if that end is not attained in an artistic manner then the result is failure.

First the projector should be set going, and if necessary given a little oil at the appropriate places. Incidentally it should be mentioned that light machine oil, preferably as recommended by the manufacturers, should be used. Heavy oil such as is used by automobiles is worse than useless, being too viscous, and will rapidly gum up light mechanism. Animal or vegetable oil should not be employed for the same reason. If in winter the projector will not rotate at the proper speed for some time due to general "gumminess," it is a good plan to use warm oil which frees the bearings in a few minutes.

The flexible shaft drive may need connecting, and when running should be examined for freedom from vibration. Usually flexible shafts are packed with grease, and scarcely if ever require attention. If, however, they show a tendency to whip or move about during running, grease may be

necessary. Because a shaft is flexible it does not mean that it should be tied in knots. On the contrary, always treat flexible shafts with due care, and let them lie as straight as possible.

It is a good plan to check the speed of turntable before each entertainment. With the use of a stroboscopic disc, as shown in Fig. 78, the testing will occupy only a minute or

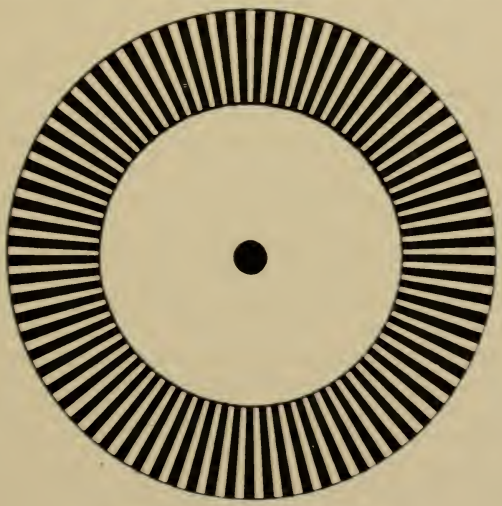


FIG. 78. STROBOSCOPIC DISC

so. All that is required is to drop the stroboscopic disc upon the turntable and examine under artificial electric light supplied by alternating current. Generally speaking, a 50 cycle supply is standard in this country, and if the correct disc is used the lines upon it should appear as stationary. If they move in one direction or the other a correction to the speed must take place. If they appear to move first in one direction and then in another something in the mechanism is not running truly. Sometimes, where damping arrangements are fitted to the turntable these get out of adjustment; alternatively, governors sometimes require a small amount of vaseline to ensure uniform running.

If alternating current electric light supply is not available the other method of checking is to count the turns. A disc running at $33\frac{1}{3}$ r.p.m. makes 100 revolutions in three minutes, a convenient check.

Testing the Electrical Equipment. The amplifier should be switched on and allowed to warm for a minute or so. Modern, indirectly heated valves take some little time before they are ready for work, so do not start film and record immediately, as there will bound to be a lack of sound at the beginning.

The usual method of testing an electric pick-up is to rub the needle sideways with the fingers, when noise should come from the loud speaker. Most ordinary pick-ups are rubber damped, as was described in the first part of this book. Rubber is apt, after a period of use, to take a set in one direction or another which throws the reed of the pick-up out of adjustment. To test for this, tap the end of the needle lightly with the nail, first one side and then the other. The sounds emitted from the loud speaker should be equal in volume and pitch.

This brings us to another point, that of needles. There are many scores of different types of gramophone needles on the market which will serve for our purpose, but generally speaking it is wise to adopt the straightforward "loud tone" variety, for electrical reproduction at all events. Do not employ any of the "soft" type. If the volume is too high, it can be lowered by the volume control. It should be appreciated that a "soft" needle is simply smaller in diameter, and permits a certain amount of vibration to be lost in the material of the needle itself.

Troubles are not likely to occur with the straightforward type of amplifier used with disc equipment except, of course, if we are adapting a radio set amplifier, care must be taken that the grid bias to the first valve is adjusted properly so that the valve is working under correct conditions, as may be found by reference to the valve manufacturers' leaflet.

In most of the modern radio sets provision is made for plugging in a pick-up, and alteration to grid bias takes place simply by the turning of a switch.

Running the Equipment. First of all the film should be taken and checked for title and then threaded in the projector in the ordinary manner, except that care should be taken that start mark is the top spool side of the film gate. Some equipments provide reflecting devices so that it is not necessary to project the actual start on the screen to know that it is in the gate. These are admirable, but if not fitted another method can be adopted. From the point of view of the artistic it is the worst thing in the world to project the start mark on the screen. An easy way out is to touch the edge of the film adjacent to the start mark with white quick-drying paint, which can be seen in the gate. Alternatively the start mark being in the gate can be checked by marking a frame somewhat above or below near the edge of the film in relation to some set point on the projector gate. This, of course, can take place conveniently only when you are running your own films, as the renters of library subjects would not be in favour of your setting haphazard start marks all over their films. In any case, that the starting frame is in the gate can be checked by looking down the objective lens. If trouble is experienced a small bulb is placed to the rear of the projectors so as to give a small amount of light to render the frame in the gate visible. A hand flash-lamp may sometimes be used for this purpose.

Having the film definitely set with the start mark in the gate the end should be taken over the remaining sprockets and tucked up on the take up spool. Next take the appropriate disc and check for title and reel if the subject consists of more than one. This should then be placed upon the turntable after removing the cap, if any. A new needle should then be fitted to the pick-up and screwed into position firmly but not too tightly. Too great effect applied to the small screw on the pick-up can easily throw it out of adjustment.

The record should be turned until the needle is on start mark. With flexible shaft drives there is always a certain amount of "whip," and it should be seen that the turntable is rotating quite freely with the needle on start mark and not tending to pull in one direction or the other.

Now turn the mechanism by hand so projector and turntable revolve together, while the needle traces its path from the quick lead in spiral to the true part of the groove. This may seem somewhat unnecessary labour, since a motor is available for the purpose. As a matter of fact, however, if the motor is a powerful one and starts off with a jerk it sometimes happens that the needle, instead of following the lead in spiral, jumps from start mark to the next groove and synchronism is lost from the start. It is better to work more slowly and turn by hand as indicated.

We are now in a position to start, but before we do so the volume control should be set to zero. It is quite permissible to fade in with sound and increase, but is very bad indeed to start off at full volume and then cut down as we proceed.

After dimming the lights in the usual manner the projector can be started. The amplifier has, of course, been warmed up as mentioned before. So soon as you hear the projector running uniformly, gradually turn the volume control until the sound is at pleasing strength. This brings us to another subject.

Volume Control. All electrical talking picture equipment is fitted with a volume control and sometimes a tone control. The manipulation of volume requires a certain amount of care and constant attention to the progress of the film if best results are wanted.

As will be known, the taking of a sound film is not a straightforward business at all, but is a whole series of scrappy "shots" which have to be pieced together afterwards and edited to form the finished film. Although modern sound technique has improved considerably there are still cases where the average loudness, or level as it is called, of one shot is higher than another. By this we mean that if we have one screen character speaking in normal tones in a room, and then change to another scene where he or she is again supposed to be talking normally the voice in the latter case may be higher or lower than the first, simply due to the fact that the level is not uniform.

Because of this we should use the volume control. The first principle of volume control, or "monitoring" as it is

sometimes called, is to keep the sound volume always natural according to the size of the picture. If, for instance, we have a scene where a singer is shown close up the volume of sound should match the size of the screen image. In most home entertainment the size of the screen will not exceed 4 or 5 ft., and thus, generally speaking, the volume should be sub-normal, or, in other words, somewhat under the loudness which would be apparent were the singer there in flesh. Most users of radio and electric gramophones like to work with the volume control set to maximum, but this will not serve for talking picture work.

Reverting again to the example of the singer, if after the close-up we get a long shot then volume should be reduced. Frequently, however, this does not happen, since quite probably the singer throughout the song was close to the microphone, and the long shot was merely put in silent. In any case, by sensible use of the volume control we can give the illusion of distance which adds considerably to the effect.

Adequate use of the volume control can also add considerably to the dramatic value of sound film. Thus if in one particular point in the film a woman screams, the volume control at the critical moment can be turned towards maximum. The effect on the audience is usually very gratifying. Incidentally if a tone control is fitted at the same time this could be turned so as to give preponderance to the top notes. Again, on the subject of tone control we should naturally accentuate the bass in a case where big guns are firing.

In professional operating what are known as "cue" sheets are sent with all films. Cue sheets are simply volume control settings for the different parts, and also special information as to the changing over from one reel to another. This latter scarcely concerns us, since we shall be employing only one projector. It used to be taken as an axiom with sound films that they should never be presented to an audience before they had been previewed. Even for amateur use this is a good plan, particularly as it enables us, if necessary, to make up our own cue sheets. As we run through the film we can note those particular parts where the volume should be raised or lowered. They can be noted on a sheet of paper

with appropriate remarks which will enable us to locate the position with reference to picture action. For instance we might note down "Burglar enters window—volume max.," and so on.

Sometimes, when convenient action is not available, we may use what is known as a "sound cue." Thus we might note down on our list, "Father says 'Remain here my girl'—volume half." We might deduce that the girl was sobbing and the recording engineer in the studios had somewhat overdone it!

Of course, cue sheets are not absolutely necessary, and good work can be done simply by rapid adjustment to the volume control while one is watching and listening to the picture. Probably most amateurs will not wish to go to the trouble of preparing cue sheets, and indeed they are not required to the extent they were in the beginning when talking picture recording was a new art.

When the end of the film runs through it is common for the disc to run on for some time, with a few bars of orchestration. A somewhat pleasing effect can be produced by turning up the volume at this point. Alternatively, if the film finishes abruptly with no music, the volume control should be reduced to zero, so that there is no grating of the needle to spoil the effect.

Loss of Synchronism. One of the disadvantages of the disc talking picture is that there is always the possibility of losing synchronism by the needle being knocked or jumping from one groove to another during playing. Always treat the turntable and pick-up arm with greatest respect while they are working. Never put your hand near them for any purpose at all. Some of the professional talking picture equipments are fitted with special guard rails to prevent casual knocks of the pick-up or arm. These precautions do not seem to have been carried to home talking picture apparatus, and it might be well worth while for the amateur to fit a suitable guard to his equipment.

Sometimes, although not very often, a needle will jump without being knocked, and thus synchronism is lost. The reasons for a needle jumping from one groove to another are several. If the needle happens to be loose in the pick-up

it may result. Again, if the equipment has been placed in an inclined position the arm will have a tendency to "drift" one way, and a particularly heavy passage of sound may do the rest. Always make sure that the turntable is approximately horizontal. A warped record may throw the needle, but if records become bent they can be straightened by storing horizontally under weights.

What is to be done if synchronism is lost? The only safe thing to do is to stop the film and start all over again. If the cause is merely needle jump, endeavour to ascertain the real reason and correct it. If the film is broken above the intermittent claw or sprocket, then it will have to be mended before going on. Above all things, do not endeavour to pick up synchronism even if your apparatus happens to be fitted with a gadget for this purpose.

There are one or two tricks whereby synchronism once lost can be regained by skilful manipulation, but it is not desirable that this should be practised with rented subjects, and in any case the methods are likely to cause damage to the disc.

Splicing Torn Sound-on-Disc Film. Sound-on-disc film can be joined in precisely the same manner as silent stock, except that on no account must frames be omitted. In an ordinary silent picture if a tear results we simply cut out the damaged frames and join together the two ends. This cannot, however, be adopted with sound film, as otherwise synchronism will be lost. The only way is to fill in the torn frames with a length of blank such as is commonly employed for leaders. Transparent film should not be used for this purpose, as it will cause a momentary flash on the screen. Opaque film is much better, although sometimes tinted film gives the best results according to the nature of the subject.

Operating Sound-on-Film. The operating of the equipment of sound-on-film is in many ways easier than sound-on-disc because there is no danger of loss of synchronism, neither does one have to expend care in setting the projector with an external start mark. Volume and tone control take place in the usual manner, but there are one or two little points which may require attention.

It is essential to remember that when operating sound-on-film we are dealing with a much greater amplification than with sound-on-disc. We have already commented on this fact in relation to amplifiers when we stated that with sound-on-film an extra valve is employed. Amplification or magnification of any physical quality results in loss of quality. By this we mean that if we enlarge even the sharpest of "snaps" the result is less clearly defined, and this applies equally well to amplification of sound recording. By this preamble we wish to emphasize the fact that in the case of sound-on-film the quality and condition of the amplifier are of greater importance than with the sound-on-disc. Even in these days, when the thermionic valve is a well-known commodity, some are distinctly better than others, particularly for sound-on-film work. In the early days of radio we were much troubled by microphonic valves, and it is essential for good sound-on-film reproduction that the first stage valve, i.e. the valve immediately following the photo-electric cell, shall be completely free from microphonic noises. This is tested by lightly tapping the valve with the forefinger when, if microphonic, it will ring through the loud speaker, gradually dying away into silence. A non-microphonic valve on the other hand, will emit merely a sharp "plonk" and die away immediately into silence.

If a partially microphonic valve is employed in the first stage our reproduction is likely to suffer, although the cause may not immediately be apparent by ringing sound. Microphonic valves are caused by a variety of troubles such as the slackness of the internal parts, which tend to vibrate particularly at certain periodicities.

Testing Sound-on-Film Equipment. So far as the projector is concerned the same tests apply here as in the case of sound-on-disc; other details more particularly concerned with the sound unit are dealt with below.

The first thing to do is to switch on the exciter lamp and check that the beam of light is falling truly upon the window of the photo-electric cell. The usual method is to apply a white card before the photo-electric cell.

Some little care must be given to focusing the exciter lamp. This operation can be carried out either by placing

a piece of white card before the cell window and working thereon much after the style as one focuses a projector lamp on the screen or alternatively one may endeavour to focus a sharp light slit on the sound gate. The former method is usually preferable, since we are dealing with a large area of light which will show whether or no colour bands are present. This latter state of affairs cannot, of course, be tolerated, since most photo-electric cells are varyingly sensitive to different sections of the spectrum.

The photo-electric cell itself can now be tested by interrupting the beam of light falling thereon. Some obstruction such as the end of a card or the tip of the finger should be brought across the beam of light at a convenient place with the volume control turned towards maximum. This should produce a thumping noise through the loud speaker. Above we referred to the necessity of using a first stage valve entirely non-microphonic in character. Microphonic valves can usually be detected by running the projector mechanism with the sound unit and amplifier switched on but with the photo-electric cell masked by a card. The vibrations from the machine, which to some extent will be transmitted to the amplifier, will then show up any deficiencies in the valve. The loud speaker should be quite silent when this test is being carried out, except possibly for a very small degree of hum due to the use of rectified current for the field coil.

An axiom of all good operating is to keep the film gate absolutely free from dust particles and fluff. Nothing is more objectionable than unsightly shadows across the edges of the disc. In sound-on-film work even greater care has to be taken with the sound gate, as even the smallest trace of dust across the gate will produce terrifying results through the loud speaker. As a matter of fact, a vibrating hair in the light path will produce a noise rarely heard elsewhere on this earth. Sound gates can best be cleaned by use of a feather or pipe cleaner. Do not use anything metallic which may raise a small burr on the edges of the metal which tends to collect dust and small scrapings from the film.

Exciter lamps have a relatively short life owing to the

fact that they are operated very near to their maximum capacity. It is well to check on the lamp from time to time to make sure that it is not nearing the end of its life. A wise precaution is always to have another exciter lamp on hand, since it is distinctly annoying to have one burn out half way through an entertainment. Sometimes, too, exciter lamps cause trouble by the sagging of their filaments which causes the beam of light thrown through the sound gate on to the photo-electric cell to come out of focus. Sometimes also trouble is encountered when the filament after long periods of incandescence stretches slightly, thereby becoming slack, which permits it to vibrate at certain notes, which may produce a result similar to that given by a microphonic valve.

Photo-electric cells, of course, do not last for ever, although the modern variety are exceptionally efficient. Roughly speaking the strength of a photo-electric cell can be gauged by its "hiss." With the equipment turned on, but with the projector itself at rest, turn the volume control to maximum, when a sort of hissing or roaring noise should be heard through the loud speaker. Always make this test before an entertainment, and by experience you will know whether the photo-electric cell is retaining its qualities. After a little experience with a number of photo-electric cells you will be able to judge the quality of the cell itself by the type of hiss produced. It should be sharp and clear, and free from noise somewhat resembling radio interference.

It must be remembered that with the volume control turned to maximum the set is very sensitive, and may, if suddenly jarred, produce a howl. This does not necessarily mean that something is faulty. Do not allow your equipment to howl in this manner, but immediately this occurs quickly turn the volume control down until the noise subsides.

As a matter of fact, the hiss of the photo-electric cell is one of the best tests of the condition of the whole of the apparatus. Thus, for instance, suppose some of the valve pins are dirty and not making very good contact, turn up the volume control and the hiss from the photo-electric cell will be interspersed with crackle. Similar results may be

produced with a dirty volume control which can usually be cured by one or two wrist movements when the wiper will automatically clear away slight oxidization or dust. If crackle is still apparent a temporary cure can often be given by touching the wire winding of the volume control with a small amount of vaseline or, better still, graphite grease. This should be applied with the tip of the finger, and be so small in amount that it is hardly visible.

In sound-on-film work it is even more important than with sound-on-disc or silent projection to make certain that all the parts are well lubricated. Any tightness, particularly of the sound drum or "movietone" sprocket may produce what is known technically as "flutter." This itself is actually a periodic variation in the movement of the film which produces a rhythmic change in pitch of the sound similar to what is sometimes noticed with cheap gramophones where the spring motors are not properly constructed or the governors are working imperfectly.

Should the equipment be fitted with a special damping device for the movietone sprocket this should receive attention. On no account, however, should any oil be permitted to creep through on to the sprocket. Oil is bad for all films, but particularly so for those bearing a sound track.

If the equipment has been out of use for some period it is well to check the guide roller: this can be done by running through a special test film, as already mentioned in connection with the "buzz" track of R.C.A. Another method sometimes adopted is to use an old piece of undeveloped negative film which is threaded through the mechanism which is then slowly turned by hand while the exciter lamp is switched on. The intense light produces a change in the still partially sensitive film, and the slit is printed as a dark line along the edge of the film. These bars representing the slit should just clear the perforations.

It is important that the take-up spool shall not be pulling over tight, since this tends to drag and cause the whole mechanism of the projector to run erratically. The same also may be said to a lesser extent of the upper magazine, which must run truly and not "lump round" due to poor rewinding.

Great care should always be taken in threading sound-on-film projectors that the loops be exactly as recommended by the manufacturers. Even in silent projection there is a certain length of loop both above and below the film gate which produces the best running results. If the loops are too long they flop about and make an objectionable noise, whereas if too small considerable strain is imposed upon the film and the picture is inclined to be jumpy. In sound-on-film this is much more important, for it must be remembered that in spite of all damping devices, flywheels, and such-like, the smoothness of running of the whole projector is linked up with the quality of reproduction. Apart from this, the more quietly a projector runs the less noise will be heard. Even the most silent projectors enclosed in the best absorbing blimp are not absolutely silent.

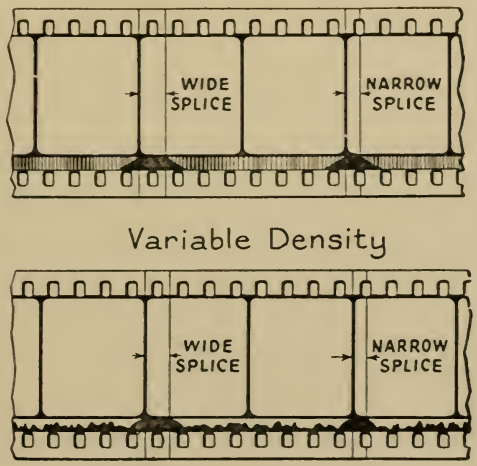
Splicing Sound Film. We have already mentioned the procedure to be adopted with sound-on-disc. With sound-on-film conditions are not quite the same, since we cannot possibly lose synchronism no matter what we do. It is best, however, to fill in torn gaps by blank film.

The splices are made in the usual manner with one of the proprietary brands of cement, but should be as neat as possible and perfectly clean. The sound track must be shaded off gradually near the join, as otherwise a loud "plop" will be heard as the join passes the sound gate. The professional method of shading is illustrated in Fig. 79 for the two types of sound track. This method should be followed also by amateurs. The illustration shows the treatment for both wide and narrow splicing, and can, of course, be adopted for either the straight or diagonal method of film joins.

It is possible to obtain a special type of ink for treating the film in this manner. Indian ink itself does not produce very good results, since it does not take very well to the emulsion.

Incidentally this shading of the sound track may sometimes be adopted where film has become partially damaged. Where the sound track is of the variable density type a repair to damaged sound track may sometimes be effected by skilful use of "movietone ink" as it is called. Sometimes

the damage in the nature of a scratch is found to one side of the track itself, which can be shaded out. When this portion passes the sound gate there will be a diminution in volume which can, however, be corrected by raising the volume control. For standard 35 mm. repairs of this nature



(*R.C.A.*)

FIG. 79. SPLICING SOUND FILMS

can be made fairly easily, but naturally they will be much more difficult with the small type of sound track on 16 mm. film.

Trouble Finding. All devices electrical and mechanical at one time or another give trouble, and talking picture equipment is no exception.

In trouble seeking in electrical equipment of this nature as with radio, it is of prime importance that some system be followed. It is practically useless to test first this, and then that, in the hope that we hit upon the faulty part. Dealing first with sound-on-disc we remember that the sound originates in the groove of the record, and is given

forth as audible sound by the loud speaker. The apparatus through which it passes is as in the following—

1. Pick-up.
2. Volume control.
3. Input transformer (sometimes this is omitted).
4. Amplifier.
5. Output transformer.
6. Loud speaker.

Suppose we can obtain no sound from the equipment when working. The procedure to follow would be to use a pair of headphones, and first of all put them across the terminal leads from the pick-up. If we hear sound in the headphones, this means that the pick-up is all right, and we must look further. Next we should test the amplifier side of the volume control, and then the amplifier side of the input transformer.

Next, turning the volume control down somewhat, we test at the output of the amplifier, where we should hear very loud reproduction. If this is absent then the fault lies with the amplifier itself, and we must utilize the circuit diagram before proceeding farther. If we happen to be familiar with radio work this should present no difficulties. Supposing, however, that the amplifier is satisfactory we can next test at the loud speaker side of the output transformer. In many cases this transformer is located near the loud speaker itself and sometimes directly attached thereto ; from this we test to the leads running direct to the speech coil.

By working in this manner we can rapidly localize trouble. On the other hand, if we merely tried haphazard at the amplifier and found no sound there we might start testing for valves, etc., when really it was the pick-up which was at fault.

For sound-on-film work we have to proceed in a different manner. We should check that the exciter lamp is alight and is properly focused. The photo-electric cell is a somewhat difficult matter, since its output may not be great enough to operate headphones. The best way of checking the photo-electric cell is simply by replacing by another which we know to be in order. If we find that replacing the existing cell by another still produces no sound we can proceed

farther. From the photo-electric cell the testing follows similar lines to that outlined above, except that the volume control will be differently placed, and is frequently situated in the grid circuit of the first valve. Manufacturers of the equipment usually supply instruction leaflets which give details of testing the circuit at various points.

It is an interesting fact that certain varieties of photo-electric cell gradually loose their sensitivity, which returns in part after the cell has been out of use for a period. Sometimes an improvement in result of a photo-electric cell can be effected by slightly twisting the cell so that the light beam falls upon a different part of the sensitive surface. Certain photo-electric cells when broken in contact with water are explosive, possibly not to the extent of causing bodily harm, but certainly with startling results. They should, therefore, be handled with due care.

Loud Speaker Faults. As already mentioned, practically all loud speakers employed for talking picture work are of the moving coil variety. Under normal conditions these are good servants rarely giving trouble. When, however, they do manage to get out of adjustment the results are usually bad. One of the chief troubles likely to be encountered with moving coil loud speakers is known as "rattle" or buzz. Loud speaker rattle *may* be caused by overloading of the diaphragm by using too large an amplifier.

Should it ever be necessary to employ several loud speakers for talking picture equipment, they should be kept towards the middle of the screen. If instead of being placed towards the centre of the screen they are placed one at each side we shall get the effect of crossed sound beams, which spoils the sound distribution in any room.

If a very large room or hall has to be covered it is a good plan to utilize what is known as the directional baffle. In ordinary use of moving coil loud speakers the instruments themselves are mounted against a hole cut in a flat piece of board. It is, of course, useless to endeavour to work a loud speaker without a baffle, since the low notes "slip round" and cancel out, thus leaving us with an unnatural buzzy top register and no bass. The directional baffle is merely a conical shaped box the taper of which need not be great—not

more than, say, 20 degrees or so. The smaller end of the baffle is closed by a flat board in which is cut a circular opening which takes the mouth of the loud speaker in the usual manner. This directional effect enables the sound to be carried to greater distances, and furthermore prevents excess sound in the seats nearest to the loud speaker. Of course, for ordinary home purposes questions of this nature do not arise.

In the case of moving coil loud speakers it is rarely possible to obtain satisfactory results by merely adding another loud speaker to the existing one. This is a case having reference to what is known as "impedance matching." Roughly speaking, we can consider the speech current running to the loud speaker as analogous to the flow of water through pipe junctions. In a properly designed set the impedance of the output transformer and loud speaker is such that a uniform flow takes place, thereby resulting in maximum efficiency. If we couple an extra loud speaker we shall upset this flow, with loss in efficiency and change in the tone of the loud speaker itself, sometimes to such an extent that reproduction is seriously impaired.

For those interested in the theoretical side of amplification the following rule may be of interest—

Impedance of loud speaker at 256 cycles = twice the impedance of the output valve.

Two hundred and fifty-six cycles is the periodicity at middle C in the pianoforte scale, and is usually adopted for matching purposes.

In the case of moving coil loud speakers an output transformer is nearly always employed when the above rule becomes—

(Impedance of loud speaker at 256 cycles per second) $\times$ (transformer ratio)^2 = 2 (impedance of the output valve).

If an extra loud speaker is employed it will usually be placed in parallel with the existing one. Thus if two loud speakers are paralleled the impedance becomes half, if three are used the impedance becomes one-third, and so on. Bearing this fact in mind the rules given above may be applied.

The whole question of impedance matching is not so

much an exact one as might be thought by the above remarks. It is ultimately one of taste as regards the tone, and if, therefore, you need an extra loud speaker the best thing to do is to connect it in parallel with the existing one. If you find the tone satisfactory it is best to leave well alone. On the other hand, if you find the reproduction unpleasant a new transformer can be substituted by trial and error or alternatively by working back in the above formulae, or a multi-ratio transformer may be used.

Loud speaker buzz is usually caused through some part of the diaphragm becoming loose. Usually the fault will be so small as to be imperceptible to the eye and, therefore, it is practically useless endeavouring to search it out. The best way of curing a buzz of this character is to run over all the joints on the diaphragm of the speaker with a good quality cement, preferably of the celluloid variety.

If, when the set is working, the sound comes feebly through the loud speaker which happens to be of the field excited type, you may suspect that something is amiss with the field supply.

Sometimes loud speakers buzz or rattle due to the speech coil becoming out of round or out of centre. Usually this can be corrected by slackening the centre screw which holds the spider retaining the apex of the cone. Considerable care should be exercised when making such an adjustment, for it must be appreciated that there is only a few thousandths clearance between the speech coil and the centre core of the magnet.

Some types of loud speakers have their cone supported round the outer rim by means of leather segments. After continued use this leather sometimes contracts, tightening up the cone and reducing volume. This can usually be corrected by carefully kneading the leather round the outside by means of a rounded instrument, such as the back of a propelling pencil which breaks up the fibres of the leather, causing them again to stretch.

CHAPTER IX

MAKING TALKING PICTURES

In the first part we treated with making records by processes adapted for amateur use. Since the disc talking picture is nothing more than the synchronization of sound with film, obviously little difficulty should be experienced in combining the functions of camera and recording turntable.

In Chapter VI, Fig. 58, is the Sheldon-Wilkinson Portable Talkiephone coupled to a projector. It was mentioned the apparatus could also be used and was indeed designed for, taking as well as reproducing talking pictures. Turning to the illustration we find that beneath the loud speaker on the lid of the portable case is a microphone. The pick-up arm is geared so that it traverses inwards at a suitable speed to cut a spiral in the usual type of aluminium disc. The flexible shaft, which in the photograph is connected to the projector, can instead be coupled to the camera. Here, then, we have the complete equipment for recording sound-on-disc pictures.

In Fig. 80 is the Sheldon-Wilkinson Radio Talkiephone, which in conception is probably the most complete equipment for home talking picture work yet marketed, and it is interesting to note that the inventor, Mrs. Sheldon-Wilkinson, appears in the same photograph.

The Radio Talkiephone priced at 55 guineas includes complete equipment for both recording and reproducing disc talking pictures. In the illustration a 9·5 mm. camera will be seen at the right-hand corner of the cabinet, mounted on a suitable stand which permits movement in all directions. To the left of the cabinet is a large electric globe with a reflector. This is for providing illumination for indoor cinematography. Rising from the base of the cabinet and supported on a lazy tongs device is the microphone. It will thus be appreciated that the equipment renders it possible for anyone to take indoor talking pictures. In fact, no difficulty is experienced in taking a talking picture of oneself

as Mrs. Sheldon-Wilkinson is demonstrating in the photograph. The Radio Talkiephone also includes a radio set, the tuning dial and controls of which will be seen to the front of the cabinet.

Turning now to Fig. 81A and B, we find in detail the turntable arrangement of the Sheldon-Wilkinson synchron-

FIG. 80. SHELDON-WILKINSON RADIO-TALKIEPHONE

ized turntable. At 81A is the upper view where we see the pick-up or recording arm and the flexible shaft and its connections, while in 81B we observe that the power is obtained through the medium of a two-spring gramophone motor fitted with supplementary gearing for connecting the flexible shaft to the recording arm to the right. The simple movement of a knob (illustrated in the photograph) throws the arm carrying the pick-up either in or out of gear, so that it may instantly be used either for reproducing or for recording.

Incidentally we may note that the traverse inwards is effected by means of a worm and worm wheel, completely

beneath the turntable, so that there are no external parts which have to be avoided during the process of setting the recorder cutter. This method of arranging for the cutting of the closely pitched spiral sound groove in aluminium discs is probably the neatest on the market, although

Fig. 81a. Sheldon-Wilkinson Synchro-Recording Motor—Top

naturally the construction is somewhat expensive and not readily adaptable to existing equipments.

The Reylik Apparatus. In Fig. 82 we see the Reylik recorder and microphone adapted for making synchronized pictures. The mechanism has already been mentioned at some length in the first section of the book in connection with home recording. It differs essentially from the Sheldon-Wilkinson apparatus just described, chiefly in that it is used for synchronizing as apart from making direct talking pictures. This means that we first take the picture and then

synchronize the sound to it. It is to be repeated that the Reylik apparatus tracks from the inside of a record outwards and is thus particularly suited for talking picture work, where the start mark is better located in the middle. The other advantages of this system have already been treated in Chapter IV.

The Stedman Portable Equipment. Early in the days of amateur talking pictures Stedman's Cinematograph

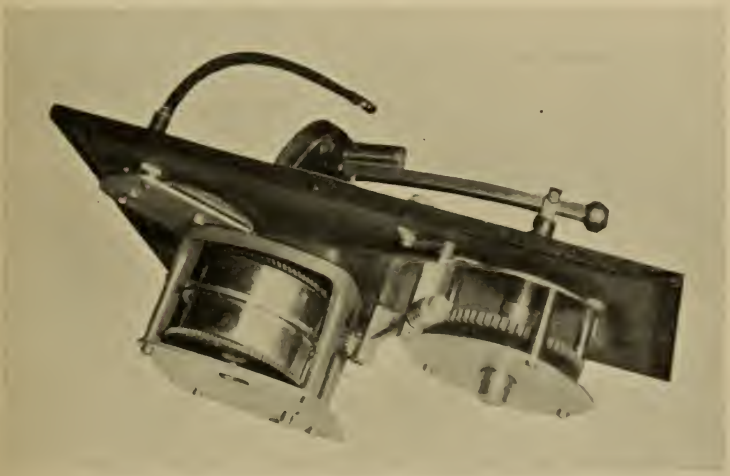


FIG. 81B. SHELDON-WILKINSON SYNCHRO-RECORDING MOTOR—BOTTOM

Laboratory of Leeds, well known in the 9·5 mm. field, produced equipment that consisted of the following units—

1. Complete 9·5 mm. projector, motor, and resistance.
2. Turntable unit.
3. Amplifier speaking unit.
4. 9·5 mm. geared camera and 6 volt motor.
5. Recording attachment.

Anyone possessing a Pathescope projector fitted with a super attachment and motor would require only units 2 and 3 for projecting synchronized film. If a radio set was employed for the amplifier then only unit 2 would be wanted.

The idea of a geared camera and a low voltage electric motor appears to be a distinct step forward in the production of a portable disc recording system. Units 2, 3, and 4

(A. W. Green, Esq.)

Fig. 82. Reylik Home Recorder

enable films to be synchronized to discs, while if original recording is to be attempted unit 5 also is required.

It must be mentioned that the Stedman equipment was made to operate at a turntable speed of 78 r.p.m., and a projector speed of 14 frames per second.

Synchronizing. We can distinguish between talking

pictures proper and synchronized versions. In the early days of talking pictures there were a number of "silents" already produced which would have been a dead loss if placed upon the market in that form. To ensure for them a certain amount of success they were "synchronized," some in whole and some in part. By this we mean that the picture originally taken silent had voice added, especially in those parts which lent themselves to the process. This type of picture has now, of course, disappeared, but a large amount of synchronizing still takes place.

Another method of synchronizing is, of course, possible—that the sound should be prepared first and the camera version made afterwards. Thus we can distinguish three possible ways of making what are substantially talking pictures—

1. Sound and picture recorded together by means of interlocked mechanism.
2. Picture recorded first and sound synchronized.
3. Sound recorded first and picture synchronized.

At first glance it would appear that the first method is preferable, since there is no question of lip movement and voice slipping apart. This is true, but from the point of view of amateur work the other methods are distinctly easier and usually produce better results. It should be emphasized that we are dealing with sound-on-disc recording.

Whatever type of talking picture we intend to make we must possess a synchronized turntable. The Sheldon-Wilkinson apparatus is capable of performing all that is necessary for home talking picture work in that it can be used for making direct talking pictures or for synchronized by either of the two available methods. The Reylik apparatus can be used for synchronizing from an existing picture, while the Stedman is roughly equivalent to the Sheldon-Wilkinson. Incidentally the Reylik can easily be adopted for use with a camera.

Essentials of Disc Talking Picture Equipment. The mechanically minded reader may care to make up his own talking picture apparatus. First of all a good type of home recorder must be purchased or constructed, according to

facts in the earlier part of this book. The only difference in this case is that we must have a means of coupling between the turntable and the camera. The actual arrangement adopted depends to a large extent upon the type of camera employed. Thus if the camera is operated by a spring motor the flexible shaft acts merely as a synchronizer and not for driving purposes. The disadvantage of this system is, of course, that the length of recording depends upon the time of running of the spring motor of the camera. Incidentally the Stedman apparatus, which provides a low voltage motor for driving the camera, is free from this objection. In the Sheldon-Wilkinson apparatus the camera is driven from the turntable motor.

In arranging the camera drive from a spring driven motor, care should be taken that rewinding is possible with the flexible shaft in position. Alternatively, if this is impossible (it is exceedingly difficult in some cases), the flexible shaft should be easily detachable from the camera, although it can be permanently fixed to the turntable.

The obvious disadvantage of the flexible shaft synchronizer is that it does not permit free movement of the camera which naturally limits the sphere of activities. At the moment, so far as we are aware, no electrical synchronizing device has been marketed, but one at least described in the next chapter has been used by the writer and found extremely satisfactory. There is no reason at all why a simple electrical synchronizer cannot be adapted to almost any make of camera. The construction of this is, however, somewhat outside the scope of the present work.

Synchronizing Procedure. The easiest method of synchronizing is, in the experience of the writer, where the sound is already in existence either in the form of a standard record or a home recorded disc, and the picture is photographed later.

The procedure to be adopted is simple. First the scenario is prepared and rehearsals conducted until both sound and action are satisfactory. It is fairly easy to make this statement, but care and work have to be expended before it becomes an actual fact. The first point to be borne in mind is that the length of the subject or "shot" must not exceed

in time that occupied by a disc, although several discs can, of course, be used if necessary.

For preliminary work the amateur would be well advised to adopt standard gramophone records, and make the experiment of synchronizing pictures to them. The writer has seen and heard a number of synchronized talking films, made from standard gramophone records, which are really excellent, especially if one does not know that the voices heard belong to different people to those on the screen. If the actors happen to be known to you it is a somewhat uncanny feeling when one sees them actually on the screen but talking with other voices!

The method of synchronizing is simply to place the disc on the synchronized turntable with the camera wound and loaded and placed nearby on a suitable support. The record is started and the actors carry through with their parts, keeping time to the voice of the loud speaker which is reproducing from the record. This may seem somewhat difficult, but a little experiment will indicate that nothing is easier. Simple instrumental synchronization can also be attempted, but beware of complications! Of course, it is permissible to have an "off stage" organ effect, but it is distinctly disturbing to find a violin in the sound when the only thing seen on the screen is someone busy with a saxophone!

If a spring-driven camera is employed one has to endure the annoyance of its running down if a long subject is undertaken. This, of course, depends upon the amount of film which can be run off at a single winding of the camera. Incidentally it may be remarked that the motor of the gramophone turntable, if a powerful one, will somewhat assist the camera and enable it to run rather longer than usual. This is an advantage that must be used with care, since an annoying drop in speed may take place towards the end. As a matter of fact, even this does not matter so much if actors respond by slowing down their actions accordingly, or in other words, still keep in perfect synchronism with the loud speaker. The writer has prepared synchronized films in this manner where, due to mechanical defects, the record had to be run at a speed of about 66 r.p.m. instead of the

usual 78. The sound from the loud speaker was, of course, appalling, and the actors had to slow down and drawl their words in synchronism. The film when projected was, however, perfectly normal in all respects, much to the surprise and satisfaction of all concerned.

Of course, the real advantage of this type of synchronizing is that silence need not be adopted. In an ordinary sound recording studio not a sound must be heard except that from the subject. This is a somewhat difficult matter to arrange, especially when one is using a noisy camera. For some unknown reason a microphone delights in picking up unwanted sounds even though it frequently misses those which we wish recorded.

Instead of synchronizing to standard gramophone records we may prepare our own disc and synchronize in the usual way. Here it must be emphasized that a great advantage is reaped by starting at the inner part of the record and working outwards, since this preserves the point of the fibre needles used in play back. In ordinary home recording adjusting the needle from one groove to another is not so very disastrous, but it is fatal for synchronizing work. If one uses a high power amplifier and heavy cutter pressure a steel needle can be employed which gives better results with freedom from jumping.

If two or more shots have to be made with the camera to complete a record it is a good plan to allow an overlap of film. Thus, if possible, we should arrange our scenario so that there are two or three distinct changes of scene according to the necessary windings of the camera, which may have to be removed for this process. One starts off in the ordinary manner, runs the scene and perhaps the beginning of the next, stops the camera, rewinds, puts back the pick-up, and picks up the second stage, and so on. An extra length of film will thus be included which contains the same action twice. This can, however, be cut out by trial and error afterwards. It is much easier to cut out pictures than to find that we are one or two frames short when we come to match up. Instead, if considerable care be taken, the whole mechanism can be stopped by using the turntable brake, but even then it is best to arrange for a change of scene

which will prevent a certain jump if your subjects happen to move during the interval.

Editing—Synchronizing. When we have prepared the length of film it has still to be matched up to disc and a suitable start mark applied to both. If an ordinary gramophone record has been used working from the outside diameter to the inner, then the start mark will have to be made as best it can on the plain rim outside. Usually this can be cut quite well with a pocket knife, if care be taken and a magnifying glass used. One of the troubles with this type of start mark is that it wears out after a number of playings.

It is sometimes recommended to put a definite starting point on the record beforehand, and make a definite indication by exposing a sign to the camera so as to locate a particular point of film and disc at which the start was made. This can be done but is not absolutely necessary. One of the easiest methods of marking the film is simply to have a prominent character cross his or her arm, or make some other definite movement. This is recorded by exposing one or two pictures, and the camera is then linked up and the needle placed on the start mark and synchronizing commences.

If this trouble be not taken the film and disc can be synchronized afterwards simply by running the sound and film together and making a series of trials, noting whether the sound is before or behind the picture, and making correction by re-threading. It may be remarked that synchronizing in this manner is not difficult when once one has attained true sense of synchronization. This may sound peculiar, but it is a fact. Few people will be able to tell, when a picture and disc are projected, whether they are truly in synchronism. If we are only one or two frames out, then the lip movement and voice may seem together, but still lack that naturalness essential to talking pictures. When picture and sound are really in synchronism we get true illusion. This can best be tested by running a film of which the start mark is known, a few pictures out. You will find that synchronism appears to be as perfect as before, but that half the illusion is missing. In other words, you see a

picture and you hear a voice, but you do not have the feeling that the picture actors are speaking.

If we are using an aluminium disc of our own recording and working from the inner to the outer diameter the start mark can take the form of a radial line which mates with a part of the spiral groove. Usually it is necessary to let the turntable take one or two revolutions to come up to speed before recording is started. The camera will, however, be running during this period, and has a record of the characters. This part can be retained while the tests are being made for synchronism, though it should, of course, be cut away and replaced by blank when the start mark has been determined.

Sound Synchronized to Picture. If we have a series of films we can prepare synchronized records. The easiest thing in the world is to prepare a commentary to an existing film after the style of some of the synchronized travel films at present somewhat popular. Exact synchronism is not essential, and one can simply run the projector at normal speed, and by means of the seconds hand of a watch note the time intervals of the occurrence of different scenes. Then working from this time-table a home record can be made. Start marks may not be necessary since a certain amount of overlap on either side is of no great importance. Generally speaking, it is wise to have the dialogue slightly in advance of the picture, so as to give the audience a chance of looking for those items to which you direct their attention.

The more difficult type of synchronizing sound to picture is carried out by connecting the projector to the home recording set. This picture can be one you already possess or one specially prepared for the purpose. In any case rehearsal is essential.

The picture is screened while the characters who are to supply the voices are situated at suitable distances from the microphone. As the film images gives mouth movements the characters enunciate before the microphone in synchronism with the picture. It will be found that this is somewhat more difficult than the reverse method of acting to sound.

One of the main points to remember is that the loudness

of the respective voices must be in accordance with the size of the film image. If we have one character close up shouting to another long shot, then the dialogue we hear must be in balance. It is ludicrous when both these people speak into the microphone at an equal distance and similar loudness.

Although, in the opinion of the writer, synchronizing in this fashion is more difficult and less likely to produce good results than the other, it has the advantage of economy. Thus if we have already mastered the art of producing and photographing the silent subject we can finish the camera work and then, if necessary, make several attempts at recording, selecting the best ones for keeping with the knowledge that the extra expense is merely a few coppers for recording discs. The other system, of course, tends to waste film rather than discs, and is thus apt to be more expensive until one has completely mastered the technique.

Direct Talking Pictures. Although this is the most difficult method of producing talking pictures little need be said on the subject, since it is merely a combination of the methods of synchronizing.

If rehearsal was necessary for synchronizing pictures it is doubly so in this case, for once recording has commenced practically no instructions can be given owing to the presence of the ever vigilant microphone, besides which the producer has to keep clear of the camera field. When one first attempts taking direct talking pictures one begins to appreciate the difficulties of the art, although they are by no means insurmountable. Unless we are very lucky indeed a certain amount of film is bound to be scrapped.

In attempting direct talking pictures it is well to start with the simplest subject such as a singer, although in all probability it could be covered better by synchronizing. Before one attempts this work also one must test the capabilities of the microphone and amplifier equipment. Some of the cheaper carbon microphones are heavily damped, and while they give reasonable quality have a short pick-up range. One sometimes finds that a microphone which will record ordinary voice perfectly at a distance of 4 or 5 ft. cuts off sharp a few feet farther on.

The type of microphone required for long shots is somewhat expensive. Perhaps the Igranic "Pentrovol" described in Chapter IV is one of the best carbon microphones for this class of work.

Microphone Placement. The usual place of the microphone is slightly before the heads of the actors, and just above the field of the camera. For a close up shot the arrangement will be seen in Fig. 83. The microphone boom illustrated can be easily constructed, although usually an

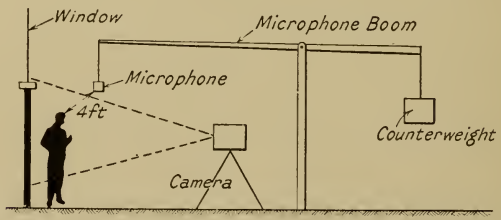


FIG. 83. MICROPHONE PLACEMENT FOR CLOSE-UP SHOT

arrangement can be made whereby the microphone hangs from some part of the scenery or studio.

For long shots the question of microphone placement is difficult. If the long shot can be arranged to cut the actor close on one side the microphone may still be placed close, although naturally the volume will have to be cut down to achieve realism.

It might be thought that we might place the microphone some distance from the actors for long shot work, but this is not the case, as the drop off in the sensitivity of the microphone is far sharper than that of the image.

Of course, there is always the alternative of concealing the microphone near the subject. Do not, however, employ heavy cloth or drapes for this deception, as they spoil quality.

Monitoring. For any direct talking picture recording the use of a monitoring device is more or less essential. The monitor can consist of a pair of headphones plugged in parallel with the recorder. Some experience is necessary before one knows the right volume to set for different parts of

the action. With the headphones go a volume control across the microphone as dealt with in the first section of the book.

For satisfactory operation of both recorder and camera two persons are necessary, one dealing with sound recording, the other with photography, following the procedure adopted in professional work.

Re-recording or Dubbing. Suppose we find that we have two home-made disc records, each of which contains a non-repeatable piece of recording which would be valuable if placed together on a single disc with a synchronized picture. How can this be done?

Re-recording or dubbing has long been a standard operation with the gramophone companies, and more recently has been followed by talking picture producers. It is a fairly simple matter to extract selections from gramophone records and re-record them to another disc. The only apparatus needed in addition to the ordinary recording machine is another gramophone turntable and pick-up. By trial we determine which part of the record we require, and mark it as carefully as possible by means of a coloured pencil.

The arrangement of the apparatus is such that we have the record from which we are to take an abstract on the turntable of the gramophone equipped with a pick-up. From the pick-up the leads run to the amplifier and thence to the recording head on the recorder machine.

All we do is to set the recording stylus at the start of the disc, and having placed the pick-up on the other machine a little ahead of the selection start both machines together operating with a volume control set across the pick-up. By use of plugged in headphones or simply by listening close to the pick-up we can hear as the selection we require comes on, and as it does so we open up the volume control so that recording takes place. Immediately it is finished we bring the volume control quickly to zero, and at the same time stop the motor of the recording machine.

A second selection can then be added by repeating the procedure, but without moving the recording cutter from its groove. There is likely to be a small gap of silence between the two, since we must allow the recording turntable to make one or two revolutions so as to attain normal

speed. Some care is necessary in adding the second abstract, since we can no longer let the recording machine run ahead a few grooves, but have to pick up the second piece of recording as quickly as possible. Actually, of course, the best way is carefully to run the reproducing machine and locate the exact point in the groove where we wish to start recording. If care be exercised it will be found possible to lift the reproducing needle from this groove one or two grooves earlier in the recording, when we can start both the machines together, and with careful listening near the pick-up raise the volume control just as the part required begins to be reproduced. The number of grooves which we allow need only be sufficient for the turntable speed of the more sluggish machine to attain standard.

Using entirely separate machines for reproducing and recording, we must take very great care that their speeds are precisely the same, and it is better to check with a stroboscope disc.

Usually this method will be sufficiently accurate for accompaniment work, but where absolute synchronism is essential it is necessary to couple the two turntables together by means of a flexible shaft or belt.

The whole subject of dubbing is an interesting one, and a field for much experiment by the amateur.

78 or 33⅓ r.p.m.? As described in Chapter IV home recording can be made on records running at a speed of 78 r.p.m. or 33⅓. From the point of view of talking pictures it will be found usually that 80 r.p.m. is preferable to 78, since this solves a number of gear problems in connection with coupling turntable with camera or projector.

For projection of home talking picture work the 33⅓ r.p.m. record has been adopted, chiefly because the subjects are borrowed from the professional films already in existence. For the making of home talking pictures, however, the 80 r.p.m. disc will be found preferable, since it gives better reproduction. The objection that it lasts for a short period of time does not hold water in this case. A 10-in. record runs for approximately three minutes, and a 12-in. record for four minutes. Home recording discs last somewhat longer owing to the groove spacing being a little closer.

In this connection the reader should refer to the table given on page 38 in connection with the Pam-O-Graph, which is fairly indicative of practice in these matters.

In the making of amateur talking pictures, the limiting factor is usually film length, and thus short playing times of records do not matter much. A three-minute talking picture may sound short, but in practice can be made to represent a nice corner in art.

If longer subjects are desired then almost certainly an electric motor should be fitted to the camera as well as to the turntable when $33\frac{1}{3}$ r.p.m. records can then be used. It must be repeated, however, that more care is required than with the 78. Until one has achieved really good results with records running at 78 r.p.m. it is useless to attempt the $33\frac{1}{3}$ record.

In concluding this admittedly sketchy chapter of the making of home talking pictures the writer wishes to emphasize the fact that "it can be done." It is not so easy by any means as making silents, simply because it is newer, and manufacturers have not yet reduced it to a "penny in the slot" process. It remains one of the most fascinating hobbies in existence, and experimenters in this field must remember that for ideas possessing real merit there is always the possibility of rich rewards.

CHAPTER X

CONCLUSION

In the past few years the use of sub-standard film has greatly extended, and is, in fact, the real cause of the popularity of amateur cinematography. Nevertheless we must not forget that there is still a number of people who use standard or 35 mm. film for home or amateur purposes. In fact, before the relatively recent boom in sub-standard film, the amateur side of the art was kept alive by a band of enthusiasts who shouldered the high cost of 35 mm. film and struggled ahead with their hobby.

In the sound picture world it is not likely that 35 mm. film will ever be adopted to any extent for amateur purposes. There is, however, another side to small size talking picture equipment, namely educational, advertising, and general industrial purposes. In this field, more particularly in America, 35 mm. portable sound-on-film equipment has attained considerable vogue, and may hold it in spite of recent advances in sub-standard sound-on-film.

The lighter and more compact type of equipment for sound-on-film for 35 mm. width is essentially portable in character, although perhaps the word "transportable" would be more fitting, since few of us would care to porter the bulky cases involved.

In general features the 35 mm. portable projector follows the 16 mm., except that the parts are more robust, and provision is made for a picture usually up to some 10 ft. in width.

The first company to introduce portable sound-film equipment was the Western Electric Co., whose original outfit is shown in Fig. 84, where we see the projector amplifier and loud speaker screen. It will be noticed in this case that a small type of horn-speaker is employed, which is preferable for halls, since it gives a better distribution of sound, as mentioned previously.

In America the fire regulations are not so stringent as

in Great Britain, and a number of types of similar projectors are in use. Recently, however, the Western Electric Co. produced a modified portable, as shown in Fig. 85, which conforms strictly to British regulations where it will be noted

FIG. 84A. WESTERN ELECTRIC PORTABLE EQUIPMENT—PROJECTOR AND AMPLIFIER

that in general construction the projector resembles the regulation model except that, of course, the usual type of arc lamp is replaced by an incandescent electric lamp.

Incidentally it is interesting to note that this last type

of projector was the one employed in 1931 in the educational tests carried out by the National Union of Teachers, aided

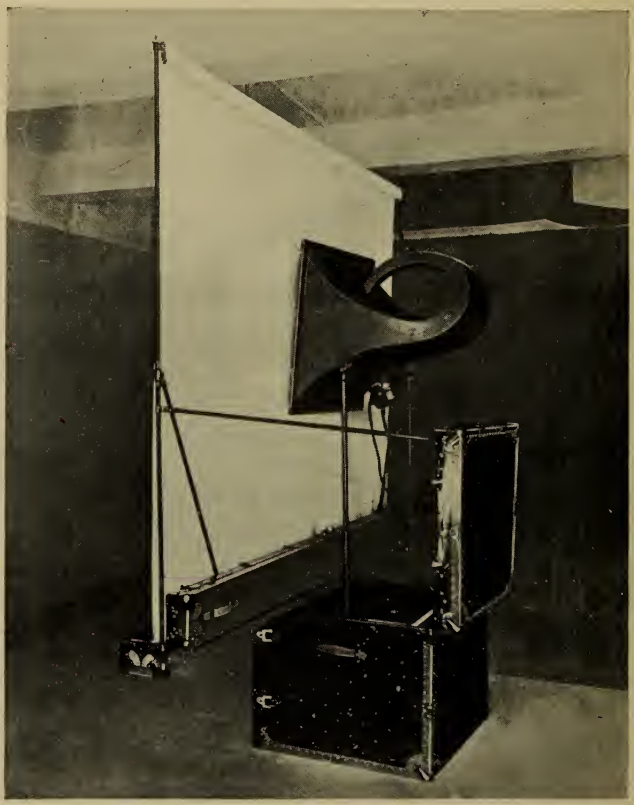


Fig. 84b. Western Electric Portable Equipment—Horn and Screen

by the Western Electric Co., British Instructional Films, and British Movietone News, where it was concluded that the sound film would prove an indispensable aid to most branches of learning.

British Acoustic Films, Ltd., also produced an interesting portable sound-on-film equipment, a general view of the projector being shown in Fig. 86. It will be noted that the whole of the equipment is contained in a fireproof case, thus keeping within the regulations.

Although for normal purposes a projector lamp marked as *Ga* in the illustration is employed, where a large picture is necessary an arc lamp can be fitted.

In Fig. 87 is the circuit diagram of the British Acoustic portable equipment which may prove of interest to those

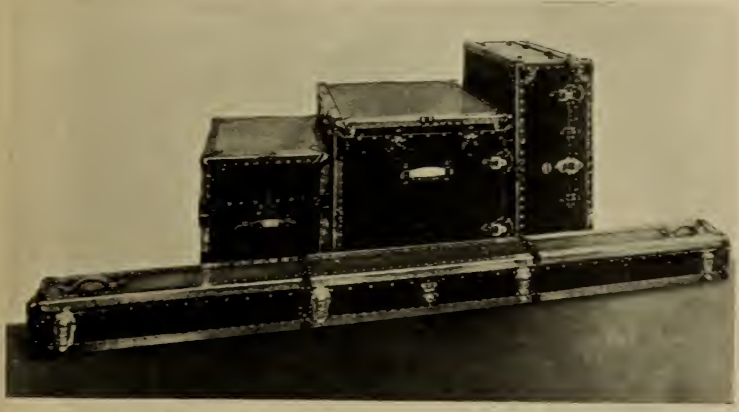


Fig. 84c. Western Electric Portable Equipment Packed

interested in the electrical side of the equipment. It will be noted that a three valve amplifier is employed, and that rectification throughout is by means of metal rectifiers.

The Day Sound Track. We have now covered the ground of present day amateur talking pictures dealing with a number of the well-known equipments. But the amateur talking picture is yet new, and new ideas are born daily, and gradually cast into metal form. A number of equipments which we have inspected are not, at the time of writing, upon the market, but show considerable promise.

It will probably have been noted that in our chapter on sub-standard sound film no mention was made of the 9·5

mm. film. Is it, therefore, impossible to put a sound track on 9 mm. film?

Mr. Will Day, pioneer of the industry, and one of the best

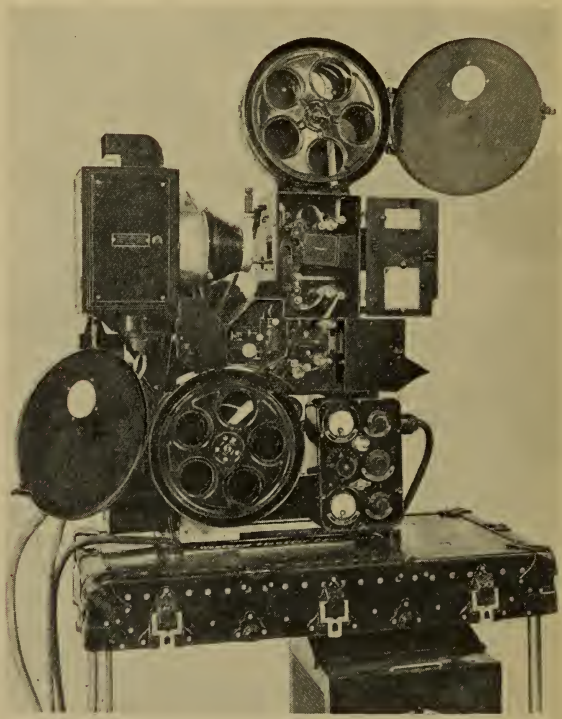


Fig. 85. Western Electric Portable Projector

known figures in the cinematograph world to-day, says that not only is it possible—it is not difficult.

When you examine a strip of 9·5 mm. film it seems impossible that a sound track could be produced thereon. But in the Day system the axis of the sound recording is swivelled round. The idea of this can best be seen by the illustrations in Fig. 88.

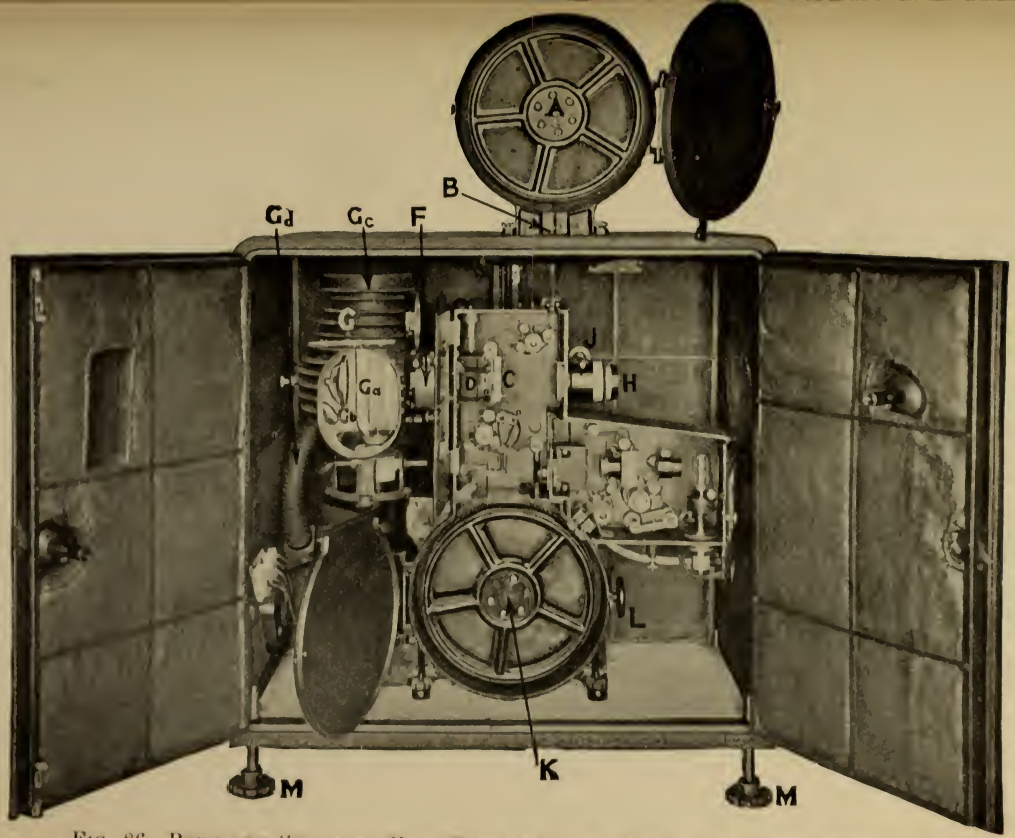


Fig. 86. Portable Sound-on-Film Equipment, by British Acoustic Films, Ltd.

In a small size film of this type the obvious difficulty lies in getting sufficient width of sound track without cutting the picture size down too much. In the ordinary way we

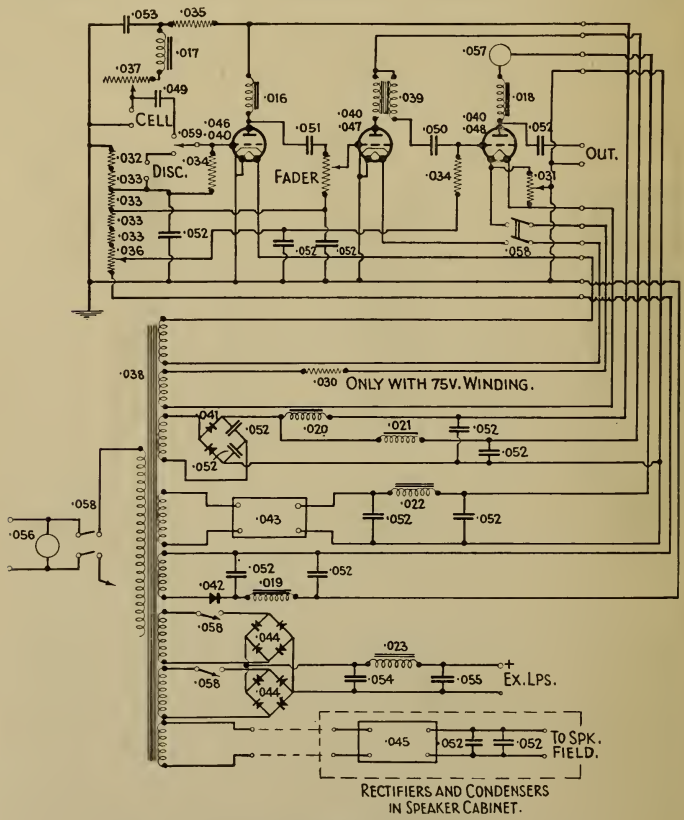


FIG. 87. CIRCUIT DIAGRAM OF BRITISH ACOUSTIC 35 MM. PORTABLE

have the sound track as shown at (A). If now we set the recorder at an angle of, say, 45 degrees, as in (B), we get the same length of sound bar in a width of sound track equivalent to ·7 of the width in the original case. If now we increase

the angle to 60 degrees, as shown in illustration (C), we find we have reduced the sound track to ·5 or one half the width required, if recording took place as in the ordinary manner shown at (A).

Clearly by adopting this principle we can put a track on 9·5 mm. film without absorbing too much of the picture. In the equipments such as the R.C.A. and B.T.-H. described in

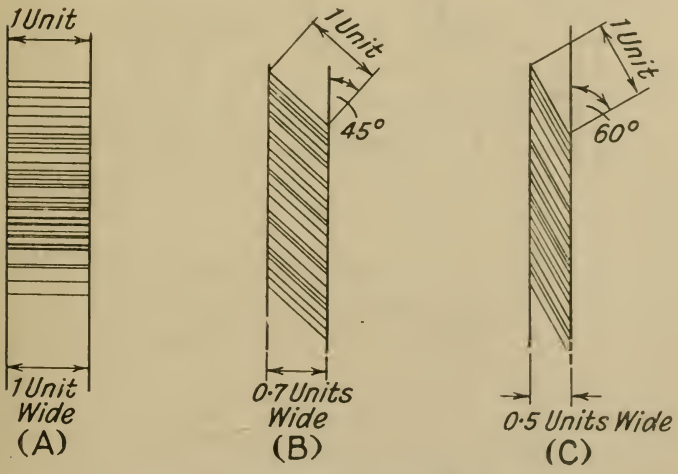


FIG. 88. PRINCIPLE OF DAY SOUND TRACK

Chapter VII we found that a sound track on 16 mm. film was entirely practicable. By altering the angle now, as suggested by Mr. Will Day, and demonstrated by him in experimental equipment, we can cut this sound track down as far as we require.

Actually this looks very much like getting something for nothing, which unfortunately in this world does not obtain. To achieve a high frequency response with this type of sound track equivalent to that of the ordinary one obviously the film speed must be increased. But this in no way impairs the usefulness of Mr. Will Day's invention, which solves the problem of a narrow sound track. It should be mentioned that the equipment produced by Mr. Will Day is an

attachment which can be fitted to existing projectors. It should further be noted that Mr. Day has actually recorded on these narrow sound tracks, and has not merely printed down from standard film as is the case of most of the other equipments at present on the market. Furthermore, we understand that arrangements are being made for the production of a sub-standard sound film recording camera which will be a definite step forward.

Long Playing Disc Equipment. Recently Messrs. Filmovox have introduced a synchronized turntable which operates at constant recording and reproducing velocity. In other words, the turntable varies its speed automatically running faster when the needle is at the inner diameter than when it is at the outside. This permits 15 minutes of recording on a 12 in. disc, thereby eliminating the necessity for the somewhat unwieldy 16 in. disc.

The principle is not by any means new, but this is the first time it has been employed for talking picture work. The theory is perfectly sound, as is the apparatus if constructed very carefully. A more serious matter is that of interchangeability of subjects, though in the projected equipment of Messrs. Filmovox provision is, we understand, to be made for home recording.

Compressed Film. In our foregoing pages we have described a number of different equipments both for sound-on-film and sound-on-disc, the prices of which vary from a few shillings for simple attachments up to several hundred pounds for elaborate instruments. One fact remains, however, and that is, no matter what type of equipment we purchase our subjects cost the same, at the moment, sound-on-disc being easier to obtain and cheaper than sound-on-film.

Twenty-four pictures a second was the standard adopted for professional sound film, both sound-on-film and sound-on-disc. As we explained previously the reason for this was that a higher film speed was necessary to enable early sound-on-film recording to approach the quality of sound-on-disc. The same speed was adopted for sound-on-disc equipments not because it was at all necessary, but simply for standardization. In professional work the cost of celluloid

is insignificant when compared with the high production cost of the film, and incidentally the rentals. But for amateur talking pictures the question is different, and it is the film cost which is troublesome. It is something of a pity that the present tendency in sound-on-disc for home purposes is to run at 24 pictures per second, since this is totally unnecessary. If the picture was good enough at 16 per second (or

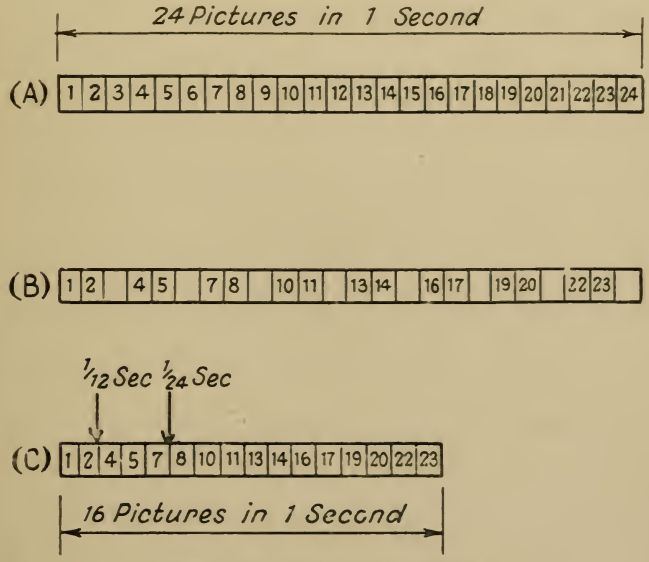


Fig. 89. Film Compression

even lower as the 14 picture per second as standard in 9·5 mm. film) why raise it to 24 per second when we have the sound recorded on a disc which is quite distinct from film speed? The real reason behind this was, of course, that most of the film subjects for amateur consumption were printed for professional purposes at the speed of 24 pictures per second.

As a matter of fact, however, this is by no means necessary, since it has been found possible to compress a film.

This process was developed in this country by the Standard Kine Laboratories, and can be explained by reference to Fig. 89, where we see illustrated diagrammatically three strips of film (A), (B), and (C). That at (A) has been photographed at 24 pictures per second, and the illustration shows "one second" length of film. In compressing we block out every third frame as at (B), which gives us the final result as at (C), where we find the length of film has now been reduced by one-third, which gives us 16 pictures for one second—silent speed.

It might be thought that this elimination of every third frame might cause the picture to be somewhat jerky in projection. However, it is rarely possible to detect that anything of this nature has actually taken place, although a little consideration will show that the time interval between pictures, say, 2 and 4 in (C) is one-twelfth of a second approximately, and not one twenty-fourth.

This process was developed in the early days when silent films still held vogue in cinema theatres, although the big film companies has ceased to produce other than talking pictures at 24 a second. It enabled the 24 a second films to be printed down to 16 a second when they were used for silent purposes.

In passing it may be mentioned that a film taken at 16 a second can be "stretched" to 24 a second by simply printing every third picture twice This is the reverse of the process given above, and can be employed when an old type silent film is to be synchronized with sound at 24 per second.

Taking into consideration the above points, it would seem a better way for amateur sound-on-disc to be run at the old silent speed of 16 per second, which can be obtained by a mechanical process of printing. It is possible that this speed may even yet be standardized, although it does not seem probable. In the equipments it will be remembered in most instances that the projector could run at the speed of 16 or 24 per second, while the turntable was rotating at a speed of either 78 or $33\frac{1}{3}$ r.p.m. This means that owners of such equipment need not worry whether for amateur sound-on-disc 24 or 16 pictures per second are eventually decided upon.

Mills Sound-on-Disc Equipment. Even with film speed of 16 pictures per second we are faced with relatively high costs. We have already mentioned the subject of libraries and the general assumption at the present moment is that the owners of amateur talking picture apparatus whether of sound-on-film or sound-on-disc type will rent their films. We understand that in America at the present time the cost of hiring sound-on-disc subjects has been reduced to a level approximately the same as was previously required for ordinary silent films.

In the Mill's sound-on-disc system at one stroke we reduce the cost of film to such a level that complete sound subjects including their disc can be *sold* at a price actually lower than that for silent films. This statement appears somewhat startling, but the system departs entirely from all previously accepted principles of cinematography.

This system is based upon the fundamental principles of cinematography, and its conception illuminates much of the present-day practice of motion pictures, and so it will be described in some detail. In the opinion of the writer, at all events, this system appears to be the one most likely to set amateur talking pictures as the most popular of home entertainments and that very quickly, providing, of course, that adequate commercial steps are taken.

We understand that the system was developed simply by logical examination of economic factors. For popularizing amateur talking pictures we have to render cheap firstly a sound projector, secondly some type of sound amplification system, and thirdly subjects. An examination of these three items indicates that the second, namely, the system of sound amplification or reproduction is the easiest one to tackle for the simple reason that some millions of homes in this country and an even greater number abroad are already equipped with gramophones of one type or another, mostly of the horn or acoustic type.

The quality of reproduction from a modern gramophone, whether of the small portable type or of the latest radiogram is reasonable. There are, of course, grades in gramophones as in most other mechanical products, still the average level is high. The problem confronting the inventor, then, was

to take an ordinary gramophone and by some means or other devise a type of projector capable of being synchronized to it. A further provision was that the gramophone could be placed near the screen, so that adequate illusion was provided. Flexible shafts and the like, which of necessity would not extend to a greater length than 3 or 4 ft., had to be ruled out.

The third economic factor was that of subjects. For popularity it was decided that these would have to be of such a type that they could be placed upon the market for a few shillings, or at least a price not greatly exceeding that of a gramophone record. This was working on the assumption that the popularity of the amateur or home talking picture should be equal to that enjoyed by the gramophone until the effects of the radio boom were felt.

On first consideration it would appear impossible to provide a projector which would be synchronized to any type of gramophone and placed at, say, 10 ft. from it without going to considerable electrical or mechanical complication. The problem was rendered more difficult because some of the gramophones likely to be synchronized were of the spring driven motor type, and some employed electric motors. Placing talking pictures on the market at a few shillings per subject seemed totally out of the question, or at least until the cost of celluloid film was considerably reduced under present day prices.

We will deal first with the question of subjects. Sound-on-film was clearly out of the question, since a minimum speed of 24 pictures per second for 16 mm. film had to be adopted, and this working on sound film prices raised subjects by 50 per cent. Quite apart from this, of course, on the present-day system of sound-on-film the use of the acoustic amplification was out of the question.

Why do film subjects cost so much? The answer is that we have to project film at a speed of 16 pictures per second, but the inventor of this system asks "Why?"

This is somewhat more difficult to answer. Until the writer had seen the new sound system in operation he would have stated offhand that 16 pictures per second was necessary to show ordinary movement. Most people would

have said the same, but we very much doubt whether the answer is correct. The whole of cinematography is based upon the law of persistence of vision, which states that a view of an object is retained upon the retina of the eye for a fraction of a second after the object itself has been removed. However, it appears that the actual time of persistence depends on other factors, such as brightness, and the time during which the eye was gazing at the object.

In an ordinary cinematograph projector the ratio between the time of projecting the picture on the screen and changing from that picture to the next along the film is constant. In this new system, however, the projector is designed upon an entirely different principle. The time of picture change is constant, no matter what the speed of projection.

The second difference is that instead of projecting at a speed of 16 pictures per second we immediately drop to 4 pictures per second, and sometimes even lower. It might be stated offhand that such a low speed of projection could not possibly portray natural movement. In fact, the writer has heard this remark made by quite a number of cinematograph engineers, but the fact remains that it is possible to attain reasonably natural movement at such a low speed when working on this system, which increases the time during which each picture is on the screen, and decreases the time interval of change.

Assuming this to be true we find that the cost of film is one quarter that of 16 pictures per second, the standard adopted for silent work, and one-sixth that of 24 pictures per second. The cost of film subjects drops very low, and we understand that it would be possible to place complete sound film subjects on the market for outright sale at a price tentatively fixed at 4s., including both film and disc.

There are several other factors in the system which make for its success. There is, for instance, the elimination of the shutter by means of an ingenious device. At a demonstration the writer saw films projected on a 4 ft. screen, and the illusion was certainly good, and only in rare instances could it be detected that a lower speed than standard was adopted.

The equipment is simple, and owes its success primarily to the principle mentioned above. In all previous systems, so far as the writer is aware, synchronism between disc and projector is obtained in a continuous manner. That is to say, the turntable revolves continuously, and is either mechanically or electrically coupled to the projector, which also turns continuously and in direct ratio to the speed of the turntable.

In the new system the turntable revolves continuously but, the projector is intermittent only. As the turntable revolves it actuates electrical contacts which send impulses to the projector *via* suitable leads. Thus in the case of projecting four pictures per second, four electrical impulses are given from the turntable per second, which are impressed upon the electrical mechanism of the projector. At each impulse the mechanism of the projector drags down the film one picture length.

The experimental model tested by the writer is shown in Fig. 90, where at *A* we see an ordinary portable gramophone. Attached to the baseboard is a special type arm which lifts out of position for the placement of a record, and is held pressed tightly to the face of the record by suitable springs. The fixing of this arm to any gramophone takes only a few minutes with a screw-driver.

At *B* is the projector. The arm contains the contact-making mechanism which is fed through wires running between the arm, projector, and mains plug which can either be plugged direct into the supply or alternatively be worked through the medium of storage batteries. This incidentally is another interesting feature of the system, namely that it can be employed in localities where electric light is not yet available.

The actual principle of working of the projector is unique. No claws of any description are employed, and the intermittent movement takes place by means of a large sprocket wheel which engages three or four perforations of the film. We are at the present moment speaking of 16 mm. film, although, of course, the equipment can be made in 9 mm. without difficulty.

Reverting to the projector mechanism we find that the

FIG. 90A. MILLS SOUND SYSTEM—GRAMOPHONE ATTACHMENT

impulses are delivered to a special type of magnetic coil, which operates on either direct or alternating current. This is thrown to action by the impulses, and picture change is effected, not as might be expected, by the electro-magnet, but by a spring. In other words, the electrical impulse gives

a magnetic pull, which does not actually operate the mechanism but winds up a spring.

At the demonstration we attended we saw some very interesting films, and must say that the quality of reproduction was excellent. Synchronism was, of course, perfect.

Another interesting feature of the projector is that there is no start mark to the film. One merely tucks the end in the top of the film gate, and pushes it down until one picture projects at the bottom. Next one goes to the gramophone and after making sure that it is wound sufficiently places on it a record pulling round until the arrow on the Synchro Disc coincides with another on the record. This having been done the needle of the sound box is placed upon the start mark in the ordinary manner. Finally, after releasing the brake of the gramophone one touches the switch seen near the pivot of the synchro arm, which sets the projector in action at the same time illuminating the 100 watt projector lamp. When the subject is finished one naturally removes the record, and at the same time cuts off the projector by a touch of this most conveniently placed switch.

It may be objected to this system that the length of subjects is of necessity limited owing to use of 78 or 80 r.p.m. discs. This is perfectly true but, gramophone records of the 10 and 12 in. variety have sold almost by the billion, and amateurs have found the amount of music or vocal matter contained thereon sufficiently long for entertainment. If the record by itself was long enough for home entertainment, then it must still remain satisfactory when illustrated by a picture. Although 78 or 80 r.p.m. is adopted as the tentative standard, there is no reason whatsoever why the equipment in the same form cannot be employed for $33\frac{1}{3}$ records, although the obvious objection is that few people have turntables which rotate at this speed. This may form an opening for the use of the speed reduction turntable illustrated in Fig. 33. By using a device of this nature it is possible to convert the ordinary 78 r.p.m. turntable into one of $33\frac{1}{3}$. One can thus use $33\frac{1}{3}$ records with ordinary gramophones, and naturally with the above described sound-on-disc system.

Certainly this system is the only one known to the present writer which enables the acoustic gramophone to be employed with satisfactory results. A further interesting feature as we examined it was that it can be employed on

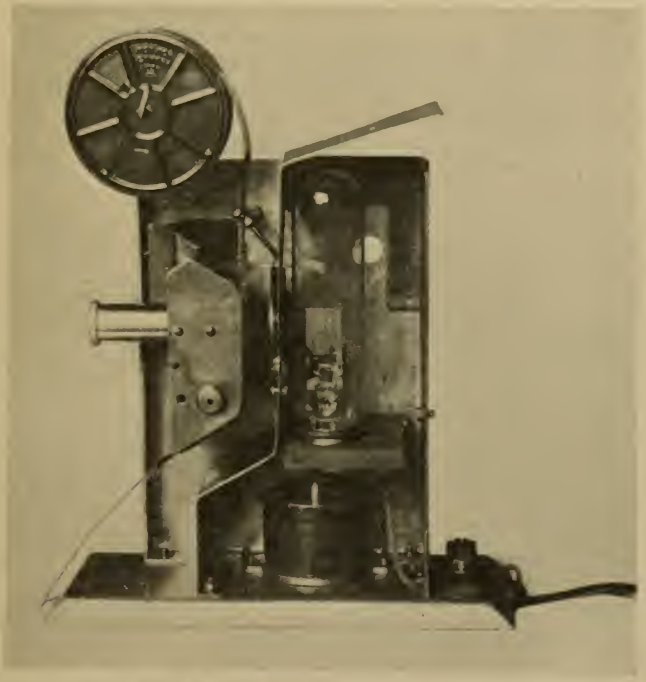


Fig. 90b. Mills Sound System—Projector

either alternating or direct current of voltages of 100 and 250, or alternatively a battery model can be supplied.

It is understood that the proposed sales price of the model is £7, including projector and synchro arm complete for attachment to any type of gramophone. It must be emphasized that the mechanism is nothing in the nature of a toy, being very solidly constructed, and giving a picture comparable in quality to first class projectors.

Mills Synchronizing Equipment. Normally a special type of camera is employed for taking these new system sound films, in which the speed of picture change is maintained constant while the number of pictures per second can be varied according to the nature of the subjects. Some subjects would naturally be projected at a speed slower than others. The system described above employs a detachable Synchro Disc which is actually a bakelite moulding easily detachable from the arm. The type of subject is to be indicated by the label colour of the disc. We understand and gather by demonstration that subjects such as singing, ordinary orchestration, can be photographed and projected at a much slower speed than others where more quicker movement takes place. In the equipment the only change necessary is to the Synchro Disc, which has to coincide in colour to the label of the record. Thus if we are using a red label record we must see that the Synchro Disc is also red. These discs are instantly detachable.

Although, as mentioned above, a special camera is normally used for taking these sound pictures, many ordinary cameras can easily be adapted for producing synchronized film. An interesting example examined by the writer was the relay attachment of a Bell & Howell 70 camera. The Synchro Arm and Disc were attached to the motor board of a gramophone in precisely the same manner as for projection, and the leads from the arm were connected *via* an ordinary high tension battery to an electrical relay which was attached to the camera.

First of all a record is made of the vocal side of the picture. This is then placed upon the gramophone turntable and the needle set to a predetermined start mark. With the camera focused on the subject and the battery connected, the turntable is started, and at the same time the switch on the Synchro Arm depressed. Synchronizing is then in process, the relay operating the trigger of the camera.

We examined a few films taken by this process and were astonished at their quality. It was pointed out to us, however, that since this was merely a "rig up," best results could not be expected. The real difficulty of the process lay in the fact that the shutter speed was too low, and that on

occasion the outline of moving objects was somewhat blurred. This, of course, was due not to picture speed but merely that of shutter velocity. It is understood that a specially simple type of camera which can be used either for synchronizing or for direct work is being developed. The system including the basic method of taking films by this new process and the apparatus devised for same is protected by letters patent.

In concluding our somewhat protracted description of this system we cannot help feeling that this is probably the best effort observed so far for placing the home talking picture on a basis which renders it likely to become rapidly the greatest home entertainer since the commercialization of radio. Commercial development should take place quickly since the idea appears so effective and free from complex detail.

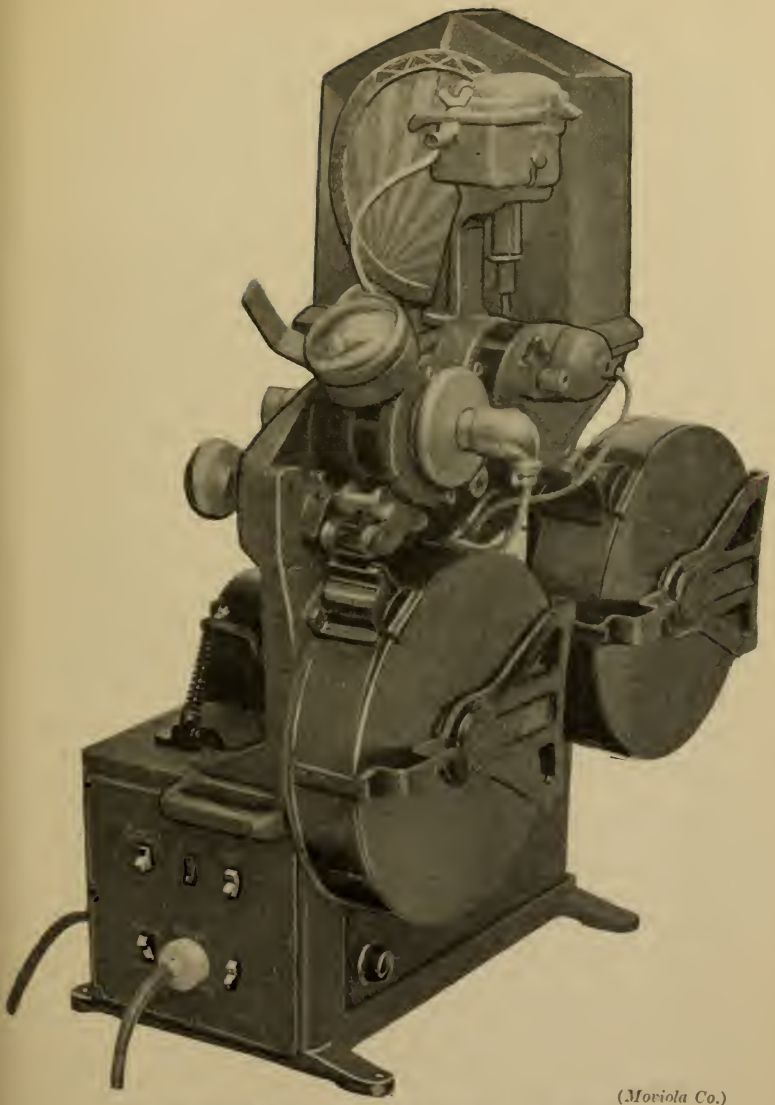
Future Developments. It seems evident that ultimately all amateur talking picture equipment will be of the sound-on-film variety. This statement may seem somewhat at variance with the remarks in the previous section. By ultimately we mean when costs have been reduced to a level so that the hobby is universal and no more expensive than present-day gramophones and radio sets. In all probability, however, before sound-on-film comes to its own we shall have a period of sound-on-disc. This is the present tendency, and may be greatly assisted by the principle described in the preceding section.

There are, however, several other possibilities for future development. It will be remembered that some few years ago a type of cinema machine enjoyed a period of popularity in which the pictures were viewed rather than projected. By this we mean that instead of using a transparent film and enlarging it upon the screen a paper film was employed, and observation was made by gazing at the film which was suitably magnified by a special type of lens. In the South Kensington Science Museum is a number of these instruments, some operated by paper strip, and some by the book principle, in which a series of leaves is clipped over at the requisite speed. At the present time the book type of moving picture has received further impetus from the work

of amateur cinematographers. It is now possible to have a strip of film made into a book suitable for carrying in the waistcoat pocket, so that one can carry a permanent record of a particularly good shot. This enables one to "show off" to one's friends without the necessity of taking them home and setting up the projector.

It is a fairly general principle that no entertainer is ever immensely popular when it restricts the number taking pleasures at the same time. This was probably one of the reasons for the decline of Edison's early peepshow "Kinetograph." Radio would not have attained its present magnitude had headphones always been necessary. For a good many years writers have been commenting upon the future "talking book." As a matter of fact the talking book is not a difficult accomplishment, and the writer has seen one of these in action. Actually it was an adaptation of the Mill's sound-system previously described. The book consisted of a series of leaves of the "flip" type which were clipped on a bracket on a gramophone. The turntable in revolving released so many pages per revolution after the style of electrical contact-making described previously. The effect was really good and presents possibilities, although in view of the possible cheapness of sound-on-disc operating on the same system it is doubtful whether the "talking book" of this type will ever become popular.

This brings us to another subject. In Fig. 91 we see the "Moviola" film viewing and sound reproducing machine. This is an apparatus employed in reviewing and editing sound films before they are released to the cinemas. In the early days of sound films editing, etc., took place through the medium of a standard type of reproducing mechanism. This had obvious disadvantages amongst which was the heaviness of the moving parts. The mechanism as shown in the illustration consists essentially of sound-on-film equipment complete. Instead of using a screen, viewing takes place through the large lens. It is possible that a miniature machine of this type might be employed for home purposes in which "viewing" took place of "projecting." Obviously a mechanism of a similar type might be also employed for sound-on-disc, indeed, one might press the



(*Moviola Co.*)

FIG. 91. THE MOVIOLA FILM VIEWING AND SOUND REPRODUCING MACHINE

argument further and use headphones which would eliminate the necessity for multi-valve amplifiers.

All this is possible, though admittedly visionary and of problematical advantage. However, one point is raised, and that is the use of paper strip instead of celluloid for film purposes. There are few things in this world cheaper than paper, and the adoption of a paper type of film might greatly aid amateur talking pictures.

As a matter of fact the use of paper strip for recording sound-on-film system has been adopted by the Austrian Selenophone Co. The apparatus known as the "Selenophone" is not at present designed for projecting apparatus pictures, but is intended to replace the gramophone. It employs instead of either celluloid for a sound track or gramophone records for discs a strip of paper $\frac{1}{2}$ in. wide in lengths of 300 metres. On this strip of paper are printed four sound tracks side by side running at a standard projection speed. A 300 metre drum gives some 70 minutes performance equivalent to about ten double-sided records. Another interesting feature of the arrangement is, that although the sound is recorded in the first place by photographic means it is reproduced by a process analagous to paper printing. Thus from the photographic sound track is made a metal plate and finally a rubber "Blanket" which is used as a printing roll much after the style of the machinery used for daily newspapers.

In our previous considerations of sound-on-film the light from the exciter lamp has been projected through the film on the photo-electric cell. In the Selenophone arrangement, however, the light is reflected, since obviously the paper is opaque. A little consideration shows this principle might possibly be adopted for other sound-on-film work. For the sake of argument we might make a 16 mm. film on an opaque base with both track and picture operating by reflected light. In this connection readers will remember the use of the old time "Mirroscope" which took the place of the magic lantern, and enabled picture postcards to be shown upon the screen. We might even run an opaque medium in which the picture was printed on one side and the sound track on the other, light being applied in both

directions. This may appear somewhat fanciful, but might not present particular difficulty. The advantage of such an arrangement apart from economy would be that the sound track could be as wide as possible, and being wide need not be so accurately made.

Taking this idea and combining it with the principles of the Moviola, we might imagine a home projector utilizing paper strip which could either be "viewed" or projected.

It would seem that these various developments which have actually taken place could be combined into a mechanism which even at the present time would give us sound-on-film results at a much lower cost than at present persists.

One of the difficulties of sub-standard sound-on-film is that of sufficient room for the sound track. A further possibility is to arrange for a track to be printed right across the picture, but in such a colour or combination of colours that while not apparent in the screen, could be picked up by a photo-electric cell especially designed or employing special filters. As a matter of fact, experiments carried out in this direction have, we believe, proved encouraging, although at the moment no apparatus is on the market.

Future of Recording. For projection we require apparatus simple in operation, and film subjects as cheap as possible. For recording, on the other hand, portability is the prime need. In Chapter IX it was found that it was not exceedingly difficult to obtain reasonable results. Nevertheless the apparatus although not heavy or cumbersome cannot be described as portable in the sense applicable to 16 and 9·5 mm. cine-cameras. Is it possible that in the not too distant future we shall be able to record sound-on-film by an apparatus more bulky than present-day silent cameras?

There is no reason why this should not be so, and a number of compact sound-on-film recording equipments are in course of development.

The real cause of the bulkiness of a sound-on-film apparatus is the necessity for using an amplifier. Even the portable equipment such as is used by the British Movietone News, although it can be transported, is far too heavy for amateur purposes.

Is an amplifier necessary? Some sort of amplification is

almost certainly necessary, but whether or no we need employ a series of thermionic valves is another matter. The invention of the thermionic valve gave us radio and modern talking pictures, and a host of other improvements. But will the valve amplifier last?

For some years experiments have been made on "valveless" amplifiers, and a certain amount of success has been achieved in this direction. For instance, a year or so ago the "Microbox" electrical pick-up was produced in this country by Messrs. S. G. Brown. This is connected direct to a loud speaker *via* an accumulator and output transformer, no intermediate amplifier being employed. The results were good, although in the opinion of the writer not quite on a level with reproduction of a first class amplifier. When you consider the method of sound-on-film recording great amplification may not be required, since we have only to vary a light beam. Perhaps the carbon type microphone will eventually, either in a modification of its present form, or in entirely new design, be made to give an output high enough to operate a sound-on-film recorder direct or through a "valveless" amplifier unit. Then again there is no reason why the light used for illuminating the subjects might not be utilized for marking the sound track. Of course, there are scores of objections to this, but it is quite possible that in the future they will be overcome, and that the recording device employed for sound-on-film work will contain neither amplifier nor recorder lamp as we know them to-day.

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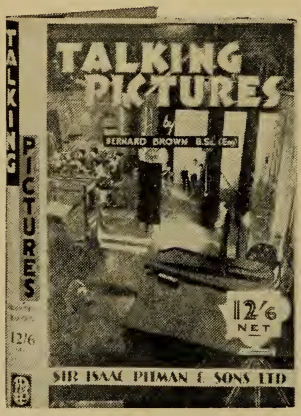

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